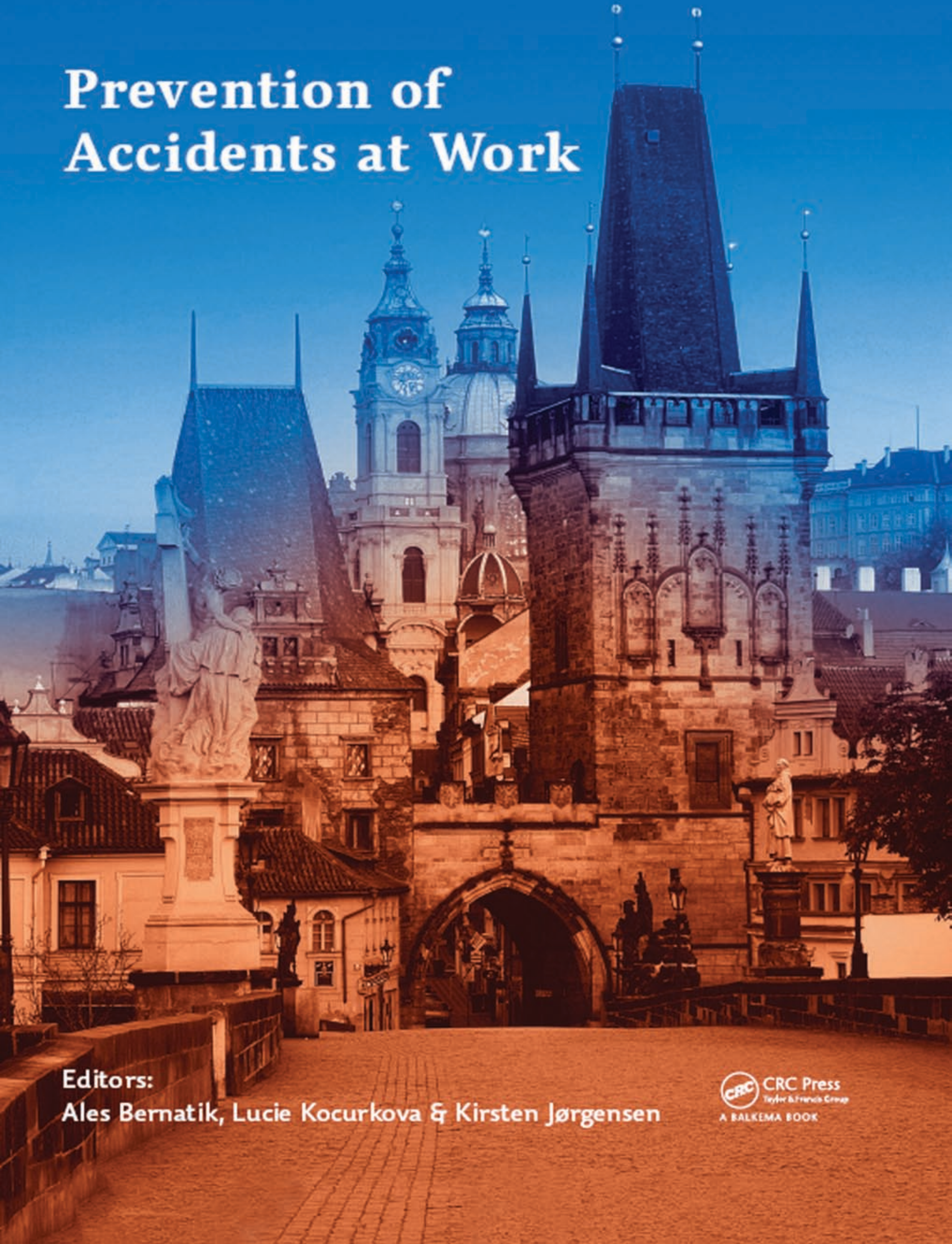
Prevention of Accidents at Work



Editors:
Ales Bernatik, Lucie Kocurkova & Kirsten Jørgensen

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Prevention of Accidents at Work

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Preface

Workingonsafety.net (WOS.net) is an international network of decision-makers, researchers and professionals responsible for the prevention of accidents and trauma at work. The network aims to bring accident prevention experts together in order to facilitate the exchange of experience, new findings and best practices between different countries and sectors. It attracts researchers, policy makers, safety professionals, labour inspectors, labour administrators and other experts in the prevention of occupational accidents and trauma and join them together in a permanent international expert network.WOS.net is supported by the European Agency for Safety and Health at Work (EU-OSHA).

A conference on current issues within occupational safety is organized under the umbrella of WOS.net. After the successful Working on Safety Conferences in Denmark (2002), Germany (2004), Netherlands (2006), Greece (2008), Norway (2010), Poland (2012), Scotland (2014) and Portugal (2015), the organizing committee of the 9th Conference invites you to Prague, Czech Republic. The hosting institution is the VSB—Technical University of Ostrava.

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Organization

ORGANIZED BY:

VSB –Technical University of Ostrava, Faculty of Safety Engineering

VSB –Technical University of Ostrava is a modern European university, whose pillars are built on a more than 165 year long history. It provides tertiary education in technical and economic sciences across a wide range of degree programs and courses at the Bachelor's, Master's and Doctoral level. Education is organized within 7 faculties and 3 all-university degree programs. The Faculty of Safety Engineering is the youngest faculty of VSB – Technical University of Ostrava. The Faculty was established on 1 August 2002 in response to the growing demand of practice for highly educated professionals in the area of safety engineering and for related scientific research activities. The establishment of the new faculty represented a continuation of a long-term process of development in scientific research activities and fields of study oriented towards safety and fire protection at VSB – Technical University of Ostrava. Graduates can take up employment as members of fire protection services, designers, safety and security engineers in various organizations, among others. After gaining adequate practical experience and authorization, many graduates can find jobs in the private sector as well.

CO-ORGANIZERS:

The Association of Fire & Safety Engineering was set up in the fall of 1993 and was registered in January 1994 at the Czech Interior Ministry. The reason for establishing a citizen's association as a non-profit organization was based on an effort to create a platform for ongoing education of members and staff members of rescue services. The Association for Fire & Safety Engineering is the publisher in the Czech Republic that focuses and bears in mind special Fire protection and Industrial safety. The leading activity involves publishing and organizing national as well as international scientific conferences.

The Czech Technology Platform on Industrial Safety (CZ-TPIS) is a civil association. The main objective of CZ-TPIS is to create networks and partnerships, to strengthen cooperation in the field of industrial safety, to promote the interests of professional organizations at both the Czech and European levels and to search for financial resources to support investment and research.

The Czech Technology Platform on Industrial Safety was founded in 2007 pursuant to the resolution of the General Assembly initiated by the Faculty of Safety Engineering, VSB – Technical University of Ostrava. CZ-TPIS operates as a national platform (NTPIS) covered by European Technology Platform on Industrial Safety (ETPIS).

OCTOBER 3-6, 2017

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ON THE PREVENTION OF ACCIDENTS AT WORK

Foundations of safety science: Theories, principles, methods and tools

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Understanding (organizational) practices in safety research: Proximity versus distance and some research implications

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ABSTRACT: Various industries such as healthcare, oil and gas as well as transport including aviation and railways, are all subject to stringent regimes relating to regulations and standardization, and extensive use of procedures in order to ensure safety. Hollnagel's (2014) view on safety through Safety-II informs us that there is more to actual safe work accomplishment than strict compliance with standards. This approach, Safety-II implies attention on work as done. That is, how work practices within an organization actually (and informally) is performed. This paper addresses the following research question: "How can we explore and understand the performance variability within work practices in safety critical organizations?" The paper draws on a perusal of safety literature together with interview and observational examples. The discussion focuses in particular on aspects related to proximity and distance, as well as meaning versus action in relation to understanding ordinary (safe) organizational practices.

1 INTRODUCTION

1.1 *Understanding work practice in organizations*

Various industries such as healthcare, oil and gas as well as transport including aviation and railways, are all subject to stringent regimes relating to regulations and standardization, and extensive use of procedures in order to ensure safety. Plans and procedures thus facilitate predictability within such tightly coupled systems. However, as the next paragraphs will illustrate, there is more to actual safe work accomplishment than strict compliance with standards.

In their article 'Bringing Work Back In' published in 2001, Stephen R. Barley and Gideon Kunda argued that the study of work processes within organizational science received little attention at the expense of studies focusing on strategies, structural aspects and the environment. Particularly, they acknowledged; *"… an absence of studies that are attentive to the situated integration of tools, documents, action and interaction"* (Barley & Kunda, 2001:89). A refocusing on empirically grounded studies of work was called on allowing detailed studies of the routine organizing of actual work to inform organizational science. Hence, applying methodologies strong on descriptive accounts were wanted (Barley & Kunda, 2001). In a similar manner, Rawls (2008) argues that knowledge pertaining to the details of work is missing simply because conventional methods are unable to provide more than mere generalities'.

Llewelyn & Hindmarsh (2010) note that despite the topic of surveillance sparks considerable interest within organization studies, there are actually few studies where one looks at how operators actually do surveillance. Contrary, the research genre *workplace studies* (Heath et al., 2000) is multidisciplinary originating from cognitive, social sciences and anthropology. What characterizes these studies are in depth interests in how routine and daily workplace activities are actually organized within complex organizational settings where technology plays a vital role (Heath et al., 2000). The environments originally studied varied considerably, some examples are the ground operations rooms at airports (Suchman, 1998; Goodwin & Goodwin, 1998), air traffic control centres (Sanne, 1999), airline cockpit (Neville, 2004) and transportation control rooms (Heath, Luff & Sanchez Svensson, 2002). The latter described in detail how London Underground operators actually constituted meaning from CCTV images. A more recent genre contribution is Christian Heath's (2012) video-based study where he explores how participants establish order and trust during art and antique auctions by relying on verbal, bodily together with tools and technological resources.

According to Suchman's concept of *situated action* (1987), plans do not determine action—they are merely resources for action. Her work illustrates how users trying to follow expert guidance systems on photocopiers based on the idea of intelligent machines failed. She challenged the idea within artificial intelligence (AI) and cognitive science at the time that machines could be designed to understand users' goals and thus guide humans to meet those goals by following a predetermined plan. Suchman (1987) showed the reasoning behind designing an ideal plan based on a presumption of compliance that did not correspond to how the plan was actually carried out in practice. Suchman argued for the need to understand the role of plans in everyday work, acknowledging that plans are static constructions while the work context is ever changing, and we rely on interpretation and improvisation in order to solve everyday challenges. Her work has had major impact on research traditions like human computer interaction (HCI) and the more socially oriented computer supported cooperative work (CSCW). Perhaps strangely that her work is seldom referred in the safety research literature although she is one of the pioneers with regard to problematize the application of plans relative to real work practices.

However, it is Eric Hollnagel and the notion of Safety-II that has sparked an interest on studying safety via focusing on organizational successes via understanding how ordinary and routine work is accomplished.

1.2 *The Safety-II perspective*

According to Hollnagel (2014) safety can be studied by studying how things go right in the organization, i.e., exploring how organizational success actually occurs. This *work as done* or Safety-II pinpoints what professionals actually and informally do when they carry out their work. This theoretical notion stands in contrast to the more traditional way of approaching safety where you focus on minimizing human error by preventing its causes. Thus, in Safety-I, or work as imagined focus is on designing barriers' in order to hinder unwanted consequences, which implies strict rule and regulatory compliance on behalf of the professionals. Nevertheless, Safety-II acknowledges that there is more to work than just following procedures. This implies a focus on understanding (actual) professional practices—particularly the sensible work adjustments relied on by professionals' when facing mundane together with emerging and sometimes unexpected situations, i.e., their *performance variability* (Hollnagel, 2014).

In "Resilient Health Care" by Wears et al. (2015), focus is on the need to improve our understanding of the characteristics of everyday clinical work. However, it is interesting to note that in the chapters where qualitative data material has a distinct role, mainly interview quotes are included, often to a limited extent. Moreover, regarding how to study everyday clinical work, Eric Hollnagel states the following: *"… the study of ECW requires that one looks at what is going on with a reasonably open mind, which means perceiving the things that are not usually seen"* (Hollnagel, 2015:146). This was a motivating factor for Klemets & Evjemo (2017) who study nurses' mundane strategies related to managing (un)wanted nurse calls using observation, workshops and interviews.

Furthermore, Hollnagel (2015) points out that there is no criteria related to the best data source, but that decisions should be based on the type of data different methods provide.

Therefore, and in line with Suchman's *situated work*, the Safety-II perspective acknowledges that work success involves more than just procedures. Thus, this paper's motivation is *how* one can study successful and ordinary, situated work practices. The paper addresses the following research question: "How can we explore and understand the performance variability within work practices in safety critical organizations?" The paper structure is as follows: The first part of the results section provides a brief overview of the prevalence of published empirical studies on practice within the safety literature in relation to the overall number of safety publications. This section presents a limited overview of the number, focus and methods applied in articles within one distinct safety journal. The next section provides empirical examples from one previous and one ongoing study from the transport sector and aviation in particular. A discussion on the pros and cons related to understanding organizational performance variability follows, ending by concluding remarks including implications for future research.

2 METHODS

The results section in this paper is threefold. The first part is a perusal of articles from Safety Science, namely two volumes, number 83 and 95. The journal was chosen strategically because it is multidisciplinary, i.e., it aims at social scientists as well as engineers and covers the interfaces between humans, technology and organizations. The review first describes the number of articles in total in each volume. Then the articles that focus on practices related to organizations. Furthermore, the number of articles which have utilized interviews or observational studies. Finally, the inquiry is whether the articles present qualitative data material in their respective results sections.

The second part presents material from an ongoing interview based study focusing on globalization and safety within the aviation industry (Evjemo & Hoem, 2017). Semi-structured interviews of various airline roles were conducted, and the interviews were transcribed, coded and categorized based on an abductive (Alvesson & Skoldberg, 2009) analytic approach.

The third part presents examples from a previous study where participatory observation with the use of video was applied (Evjemo, 2003). The transcripts have been re-made for this paper. The study was explorative with a particular focus on what characterizes reliable teamwork within an airline cockpit. The video sequences are coded and analyzed in accordance with the analytical perspectives of ethnomethodology (Garfinkel, 1967), and conversation analysis (Sacks, 1992).

3 EMPIRICAL RESULTS

3.1 *Number, focus and methods in a safety journal*

Looking at Table 1, we note that volume 83 contains 12 articles, while volume 95 contains 19. Actually, it is not always straightforward to determine which methodological approach the authors have used by reading only the abstract. Nevertheless, the articles in the two volumes explored show relatively large methodological variation in their research designs. The articles vary from qualitative fieldwork such as the work of Haavik (2017) describing *sensework* in remote and harsh oil and gas environments, to quantitative approaches to behavior such as the *Leader-follower* model for simulating social collective behavior (Fang et al., 2016).

Regarding thematic focus, Table 1 illustrates that there are a large proportion of articles focusing on relationships linked to an organization and or processes. This implies that the articles in one way or another describe events and or entities that unfolds within an organizational context, such as the article by Goerlandt et al., (2017) focusing on ship convoy navigation in order to generate both qualitative and quantitative knowledge regarding distances between vessels in relation to ice conditions.

When it comes to the use of interviews and or observations, (mainly) interviews are in use in 7 out of 19 articles in volume 95, while for volume 83 this is almost absent. Example from Volume 95 is Teperi et al., (2017) and the study of human factor procedures relating to the reporting and analysis of nuclear energy operational events. Interviews with safety experts and managers were conducted to evaluate current HF practices, and the findings are presented in table format. Moreover, in their mainly quantitative based study of assessing safety culture in nuclear power plants (Schöbel et al., 2017) 15 interviews were conducted. However, quotes from the interviews are not presented in the article text. In fact, only Haavik (2017) in volume 95 has used both observational and interview data where explicit quotes from the interviews are included within the article text.

Table 1. Overview of content in two Safety Science volumes.

Safety Science	Volume 83 (March 2016)	Volume 95 (June 2017)
Number of articles	12	19
Focus on organizational practice	10	10
Using interviews and/or observations	1	7
Showing (qualitative) empirical data	–	1

3.2 *Understanding practice through interview*

Both management and operational staff have experienced significant changes in the airline company in recent years due to major changes in the aviation industry. Characteristics in this context are market liberalization within the EU/EEA, which has led to free competition between airline operators in the market. This has resulted in increased pressure on keeping costs down. At the same time, the industry experiences new forms of organization of airlines, including outsourcing of key business functions and the use of recruitment agencies for cabin crews and pilots.

In particular, operational personnel notice the company's increasing focus on keeping costs down. The following quote from a cabin attendant illustrates today's demanding work situation: *"… Yes well, it's the longer days and new agreements have been negotiated, which are more efficient and get more productivity. So it is, become longer days and less free"* (cabin attendant). She continues by stating: *"… You really need to perform at your best. To get this to work"* (cabin attendant). Furthermore, one pilot comments the following: *"…As a pilot, a regular working day if you can call it. They have become tougher over time. Today I think that yes, it is that a pilot should produce approximately seven hundred block hours"* (pilot). This is a marked increase compared to fifteen years ago, when the number of hours per pilot was in excess of four hundred block hours a year. An aircraft technician describes similar conditions related to aircraft maintenance during the night shift: *"… We notice it at night stops here, for example, the hangar is almost full every night. Time is pressed. The pressure is on, more and more work on each individual technician"* (technician). This usually goes well as long as you do not experience anything unforeseen during the maintenance. The challenge is that unforeseen things tend to appear often, usually daily according to our technician. An example is when replacing the air filter and at the same time detecting a crack in one of the pipes. With the current staffing, you do not have enough resources to deal with such incidents. At the same time, the missing parts need ordering which results in delays in getting the plane ready.

In the quotes above, we see that the operational personnel describe hectic and demanding working days, which according to the informants can challenge safety. This is mainly about consequences related to fatigue due to long and challenging work periods, as well as less time to carry out specific tasks during the actual flights.

However, it is pointed out that time is the most important resource, which means that extra time is an additional resource needed to handle unforeseen events when they occur. The point is that when you cut down on the time available, you will eventually reach the point where you only have enough time to do what you initially planned. An example is the short time the plane has on the ground between the flights, the so-called turnaround time. The pilot explains: *"… there is less breathing space, it requires that you are disciplined in relation to established procedures. Then it is possible. However, somewhere it says stop. Then you cannot be more efficient. Does this mean twenty-nine minutes or twenty-eight minutes? You have little time to create a backup plan or to get an overview. So it's a trade-off"* (pilot) Hence, if you are delayed, according to our interviewed pilot, there is a lot of experience in the company's pilot corps. The following example illustrates how to handle a delay: "… *Let's say that the fuel arrives late because of morning rush hour, causing delay. It may also be that there were challenging weather conditions on the way to the airport, which delays the return flight. Let's say that you are waiting for the airplane to fly back. You know that there is already a 10-minute delay. The question becomes, what can be done to cut down on time, safely? It can be something I use to do. Instead of first going into the plane with all the equipment, I take out a yellow vest and hearing protection, which I always carry in my flight bag. Which means I can go down and make the external pre-flight check of the airplane once the engines are shut down. There is a lot of experience in the airline's pilot corps, and the pilots make such assessments themselves. But it is clear, time pressure is a factor. One must know when to take a timeout"* (pilot).

Time management is something that the company focuses on in relation to the role of the captain. When appointing new captains it is important that the candidates reflect on the new role as commander and responsible for the aircraft. The point is that you are aware of the tools available for dealing with things that may be stressful, such as the commercial pressure versus when unforeseen events occur. The point is that with experience the ability to build a small buffer is also developed so that you are able to plan ahead: *"… because if something happens, everyone turns to you and asks what to do now. You must already have thought about this in advance"* (pilot). For pilots, cabin crews, and aircraft technicians ordinary workdays including work tasks are highly regulated. There are procedures and checklists for virtually everything, which means that challenges per se arise when unforeseen things occur. Nonetheless, compliance with regulations during work does not mean absence of interpretation and improvisation. Our interviewed technician explains that the rules and regulations prepared by EASA (European Aviation Safety Agency) are often quite general, which implies that: *"… Tools, it says you have to have tool control, in EASA. However, there is very little about how you intend to do that. That's what we need to elaborate. How do we intend to comply so as to maintain control. Describe such things in more detail"* (technician). According to EASA, all Part-145 organizations are required to formally describe own work processes related to aircraft maintenance, that is, how to work and how to operate the company. The examples above have illustrated that airline personnel use vivid examples when they contextualize ordinary work practices.

3.3 *Understanding practice through (video) observation*

The flight deck in a commercial jet airliner is in many ways similar to *centres of coordination* (Suchman 1997) due to the many technological resources available for the pilots, from LCD displays showing navigational and engine status, communication devices together with written resources such as various check-lists.

There are also manually operated devices such as the gear handle, flaps lever, speed brakes, control yokes and a complex array of switches and knobs to push and turn. The flight deck is thus a complex work setting by way of amount of information flow and tight couplings regarding events unfolding. Events during a flight are well known and standardized, and something the pilots expect to occur. However, unforeseen situations occasionally interfere, such as unanticipated and rapid change of weather.

Three pilots are currently present in the Boeing 767 cockpit, the captain sitting in the left-hand seat, the first officer in the right and the flight officer behind and in the middle. The aircraft now approaches the destination airport and thus descends. Pilots perform their work tasks according to a strict division of labor based on roles (pilot flying vs. pilot not flying). In Figure 1, the first

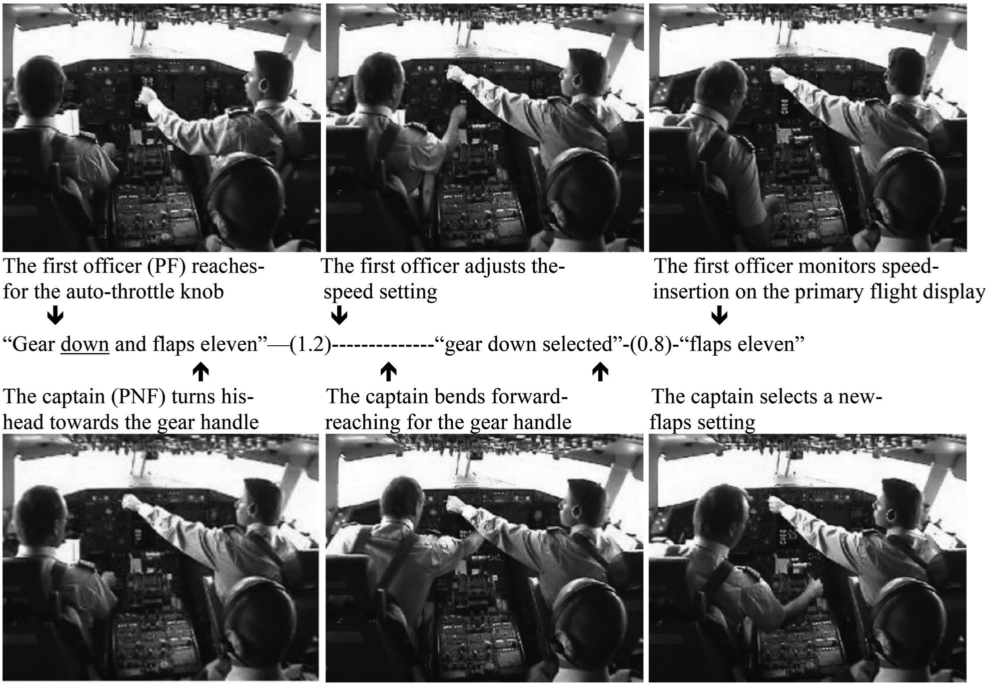

Figure 1. "Gear down selected".

officer flies the aircraft while the captain handles communication with air traffic control (ATC) on the ground. The flight officer in the middle does not have any formal task responsibilities during approach and landing beyond to monitor and assist if needed. The first officer (PF) asks the captain to lower the undercarriage by uttering: "… gear down and flaps eleven", which results in the captain leaning forward towards the gear handle and the flaps lever while he simultaneously states: "… gear down selected", followed by: "… flaps eleven selected".

Let us now take a closer look at the actions related to the lowering of the flaps. The first officer initiates the sequence when he asks for lowering of gears and flaps. The PF is responsible for instructing the PNF to assist in the practical task of lowering the flaps. The correct flaps configuration is of vital importance for the aircrafts' landing performance since flaps enable the aircraft to approach the runway at a lower airspeed. Simultaneously with stating: "… gear down and flaps eleven", the PF leans towards the autopilot panel to insert a new airspeed. This action on behalf of the first pilot is clearly visible for the captain. In the same way, the captain's actions are easy to follow, which allows the first officer to ask the captain to lower the undercarriage and flaps to 11 degrees in an efficient manner. Hence, the first officer coordinates his own task, that of managing airspeed, with initiating the captain into supporting him at just the right moment prior to the speed reduction. The captain, who is at this point facing forward, reacts almost instantly to the explicit request put forward by the first officer when first looking at, then immediately leaning forward pulling the gear handle downwards, followed by the flaps handle. The captain also confirms verbally what he is doing by saying: "… gear down selected" and "flaps eleven". The first officer is now ready for the next request—that of asking the captain to lower the flaps even more. This interaction between the two pilots is sequential and characterized by turn taking.

Actions in the cockpit are not always procedure-controlled, as the following example illustrates. In Figure 2 the captain reminds the first officer that ATC has cleared them for landing shortly in advance by stating to the first officer: "… you are cleared to land". The captain moves his right hand back and forth while at the same time turning his head towards the first officer. The captain thus warns the first officer (PF) that they might encounter turbulence during final approach, vital information for the PF to have. The two examples illustrate that pilots rely on using an array of

The captain raises his right-hand — The captain moves his right-hand back and forth — The captain points towards-the gear handle

---"It might be some turbulence when we approach the ground--(8.8)-----"you are cleared to land"

Figure 2. "Turbulence".

resources when organizing and configuring ordinary work practices.

4 DISCUSSION AND CONCLUSION

4.1 *Proximity versus distance*

The following quote describes what type of data an interview traditionally provides: "… *we can learn also, through interviewing, about people's interior experiences. We can learn what people perceived and how they interpreted their perceptions*" (Weiss, 1994:1). Interviews provide us data about expectations and attitudes of those interviewed regarding the topic of interest. In this way, the understanding of meaning is particularly relevant. Moreover, one is interested in getting the informant to reflect on own knowledge (Tjora, 2010). It is therefore important to remember that the data generated through an interview is subjective in the sense that those interviewed interpret their own experiences and may have agendas related to how one wishes to appear. There are also different types of interviews, such as depth interviews versus focus group interviews. Open or closed questions may also have an impact on respondents' ability to tell their story.

On the other hand, the principal argument for using observation is a desire to understand what people actually do (Tjora, 2010), which means that in the study of work practices in organizations, observations can help identify what people actually do, contrary to what they often say they do. According to Fangen (2010), through observational studies, you can study what activities people perform without necessarily asking questions. One distinguishes between participatory and non-participating observation roles, where one often sees a part-participatory role in social science fieldwork. This means that you participate in the social or organizational environment, but not in the environmental-specific activities, i.e. work activities per se. Video based observation studies is often used within the aforementioned workplace studies (Heath et al. 2000). The purpose of using audiovisual recordings is primarily the desire to study the details of interaction including the use of technology while acknowledging "… *the situated and interactional accomplishment of practical action*" (Heath et al. 2010:1).

That said, let us now look at two examples from the results section and we begin with the interviews of airline employees. Consider the example where the pilot explains how to save time on delay by having a separate yellow vest available in his flight bag. Through the pilot's description of own actions, in this sense *sensible work adjustments*, one achieves what can be called a somewhat distanced understanding of the *performance variability* (Hollnagel, 2014) related to dealing with delays. As scientists, we do not know exactly how this practice actually unfolds in the daily work since we only have the pilots' own expectations and experience, hence only the *meaning* dimension. Now consider the pilots in Figure 2 when they are on final approach for landing and the captain indicates to the first officer that there might be some turbulence coming up by way of verbally announcing this knowledge. This information further strengthens when the captain also moves his right hand back and forth. Thus, the first officer is now prepared. What we have here is a descriptive account of what is actually going on—the unfolding of naturally occurring interaction and the resources the pilots rely upon in order to organize and accomplish work. What we do not have is a deeper understanding of the reasons why the captain has this knowledge of local wind conditions, as well as what it is that makes him decide to share the information right now. Thus, our understanding related to the captain's actions or sensible work adjustments can arguably be somewhat distanced due to having only the *action* dimension.

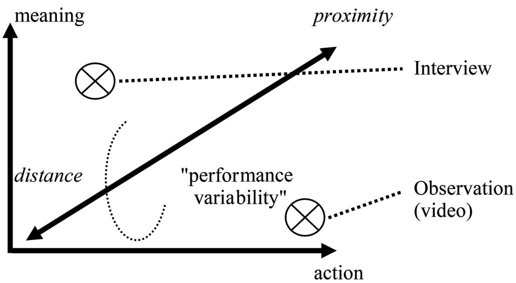

Figure 3. Understanding performance variability via distance and proximity exemplified by interview and observation.

Figure 3 introduces the dimensions of *distance* and *proximity* along with *meaning* and *action*. The point of these dimensions is to visualize the inherent potential that interviews versus observations hold in terms of describing and explaining organizational practice related to performance variability. Figure 3 implies an idealistic representation of the properties of the methods. It illustrates a continuum related to the phenomenon of performance variability, depending on how one chooses to design a research project methodically. Consider again the captain's explicit hand movement in Figure 2. Without video observation, one will most likely not have access to this type of action, which is also a situated action (Suchman, 1987) per se. *Proximity* implies an understanding of practice grounded in both actual actions and appurtenant construction of meaning. Similarly, *distance* indicates removal from the two dimensions action and meaning, which may be a gradual process. The achievement of *proximity* will in this context mean to be able to identify and understand *work as done* (Hollnagel, 2014) by acknowledging the need to uncover the what, how and why something happens. Similarly, the dimension *distance,* is related to work as imagined.

4.2 *Conclusion*

This paper started out with a refocus on empirically grounded studies of routine organizing of actual work primarily as a need highlighted by Barley & Kunda (2001) for organization science, but also visualized through the workplace genre's focus on the details of naturally performed work (Heath et al., 2000). Through Suchman's (1987) approach to plans versus action coupled with Hollnagel's (2014) safety-II and *work as done* as motivational aspects, this paper starts with how we can explore successful and ordinary, situated work practices. The paper addresses in particular how we can explore and understand performance variability within work practices in safety critical organizations.

Although this paper is based on a rather limited perusal of the safety literature, the results indicate that safety research largely lacks qualitative research designs where focus is work practices studied in detail via using video and or interview. Thereafter through exploring empirical examples, interview examples illustrated that airline personnel rely on vivid examples when they contextualize ordinary work. At the same time, video examples illustrate that pilots rely on using an array of resources when organizing and configuring ordinary work practices. Therefore, this paper argues for the necessities of conceptualizing the type of knowledge gained through different methods in four dimensions. In particular, the point is to make future research designs recognizing the *proximity* dimension as an ideal.

Based on the above arguments, the article concludes that researching ordinary and successful work practices implies a combination of interview and observation in order to uncover the details of performance variability and *work as done* (Hollnagel, 2014). This is also an implication for later studies. In this context it is further appropriate to again argue for more studies of ordinary work practice in safety critical organizations including conscious choices related to methodology and research design.

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A multi-perspective account of safety (MUPSY)

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ABSTRACT: Many aspects of safety work, i.e. the things people do to prevent accidents, tend to remain invisible or tacit, sometimes even to the actors themselves. This invisibility poses methodological challenges for researchers and practitioners who try to learn from successful (i.e. safe) operations. We comment on the visibility and invisibility of safety work and describe the process of developing a multi-perspective account of safety (MUPSY) as an attempt to sensitise practitioners to actions, patterns of interaction and practices that contribute to safe operations.

1 INTRODUCTION

1.1 *"How people work is one of the best kept secrets in America"*

This statement by the sociologist David Wellman, which was reiterated by Lucy Suchman (1995), forms a starting point for this paper. We shall argue that the statement even applies to safety work, i.e. the things people do to prevent accidents. Surely, huge amounts of work descriptions, procedures and safety rules have been produced by business organisations, consultants and researchers over the years. This paperwork does make certain aspects of safety work visible. However, we shall argue that many things people do to build safety tend to remain invisible or tacit, sometimes even to the actors themselves. This invisibility poses methodological challenges for researchers seeking to build a qualitative account of safety. We shall further report on our own efforts to sensitise people to safety work and to build a qualitative account of the things people do to build safety (Rosness et al. 2016a). On this background, we shall make further comments on the challenge of making safety work visible.

Our interest in making safety work visible was aroused through our work with the project "Learning from successful operations", which was sponsored by the Norwegian Research Council through the PETROMAKS 2 programme. The project was motivated by the observation that accident-free operations have received less attention than accidents, both from safety scientists and practitioners. The overall objective of the project was to develop knowledge and guidelines for improving the learning from operations that do not result in major accidents. We learned from our own observation work that it is not straightforward to pinpoint how aspects of normal work performance contribute to safety. Even the people who do "the right things" can not always put into words how their practices contribute to safety. Based on this, we concluded that making safety work visible could be a reasonable first step towards learning from successful operations.

The paper addresses the following issues:

1. To what extent is safety work visible to the people involved and to outsiders?
2. What makes some aspects of safety work less visible than others?
3. How can people be sensitised to safety work, so that formerly invisible aspects of safety work are made visible?
4. How can organisations learn from successful operations by making safety work visible?

The paper falls into two main parts and a final discussion. The first part comments on the visibility and invisibility of safety work. The second part describes the process of developing a multi-perspective account of safety (MUPSY) as an attempt to make safety work more visible. The term 'multi-perspective' implies that the account seeks to combine several theoretical perspectives on safety. MUPSY is intended to sensitise the user to actions, patterns of interaction and practices that contribute to successful (i.e. safe) operations.

1.2 *Relations to the work of Barry Turner*

This paper is related to Barry Turner's work on Man-Made Disasters (Turner 1978, Turner &

Pidgeon 1997) in at least three ways. First, Turner's work added to our understanding of the preconditions for large-scale accidents. The study reported in this paper sought to extend such efforts to the study of safety, and more specifically to support the capacity of practitioners and researchers to identify actions, patterns of interaction and practices that contribute to safety. In this way, the present study can be seen as an effort to extend qualitative safety research from a focus on accidents to a focus on safety work. Secondly, Turner's work is concerned with the organisations' ability to "see" the problems that may eventually turn into a disaster. The account of safety presented here aims to enhance the capacity of people and organisations to "see" how they build safety, i.e. to sensitise people to actions, patterns of interaction and practices that contribute to safety. The account thus shares an epistemological interest with Turner's work, while being complementary in its focus on safety work. Thirdly, Turner's work on man-made disasters provides a perspective from which disasters are viewed as the outcome of deficiencies in an organisation's collection, sharing and interpretation of information relating to its potential for experiencing a disaster. This information processing perspective is included as one of several perspectives used in our account to help people recognise safety work.

2 ACCOUNTING FOR ACCIDENTS VERSUS ACCOUNTING FOR SAFETY

Accounting for accidents has one great advantage over accounting for safety: it is much easier. There are a couple of important reasons for this. First, one is never in doubt about what is to be explained, or what this is really a case of—namely the accident that undoubtedly has taken place. Secondly, there exists a strong discourse of associating what has gone wrong with what has been done wrong. This, combined with the presupposition that safety is embedded in unambiguous descriptions of how things should be done right (e.g. regulations, procedures, work process descriptions), makes it fairly straightforward to compare the actual accomplishment of work with the prescriptions of work, and associate the causes of accidents with the gaps found through such comparisons.

However, there seems to be an increasing interest in a different approach to safety where one seeks to account also for successful operations instead of merely failures. This interest is perhaps most evident in works associated with High Reliability Organisations (HRO) and Resilience Engineering (RE), two perspectives that explicitly have grown out of an interest in successful operations. While HRO grew out of studies of extraordinary and surprisingly reliable organisations (e.g. LaPorte & Consolini 1991), RE has perhaps had a greater interest in everyday work. While this interest in everyday work has been evident for a long time already, the developments have perhaps been greater for the viewpoint and its philosophical underpinnings than for the methodology required to support such a programme.

How does one account for successful work? To use the above portrayed comparison with prescribed work would not be laudable, since that would imply the tautological argument that "this was a success because actual work practices followed the prescriptions of successful work". In addition to this difficulty, one might suspect that the clever notion of safety as a dynamic non-event (Weick 1987)—including the statement that these events by definition are characterised by invisibility—has also caused the unintended problems of functioning as a barrier against efforts to account for successful work.

Another challenge is related to Turner's finding that major accidents are regularly preceded by an incubation phase, during which the organisation fails to notice or misunderstands danger signals (Turner 1978, Turner & Pidgeon 1997). Seen from inside the organisation, the incubation phase is by definition not distinguishable from a situation where dangers are well controlled. Determining whether operations are safe may thus be the first challenge in learning from successful operations.

In the larger domain of sociology/anthropology/psychology of work, there is a rich literature dealing with the characteristics and peculiarities of everyday work. Also in this research tradition and literature there exists a discourse on invisibility of work. In contrast to safety science, this discourse has functioned less as a barrier against further exploration, and more as an inspiration to continuously expand the domain of the visible. What you look for is what you find (WYLFIWYF; Lundberg et al. 2009), and the ambition to make work visible signals a slightly different agenda than the labelling safety as a non-event. The result of this is evident in the larger repertoire of theory and methodology of making work visible (Hampson 2005, Suchman 1995, Star 1991, Heath & Luff 1992).

In this paper we want to direct attention towards the possibilities for using a selection of some of the more influential safety perspectives as a sensitising aid to account for the ways in which people work to create safety.

As we are looking for ways to make safety work visible, we adopt the safety perspectives together with the mentioned STS (Science and Technology Studies) perspectives that are particularly fruitful for making work visible. Among the repertoire from STS is the non-discriminant and intermixed inclusion of social and material/technological aspects in the empirical accounts and analyses, and the same openness towards the mundane as the presumptively more important and systemic features of sociotechnical systems. We suggest a possibility of enrichment of the safety perspectives and their applicability in empirical investigations by doing this, in ways that will be further elaborated on in the next section.

3 BUILDING A MULTI-PERSPECTIVE ACCOUNT OF SAFETY (MUPSY)

3.1 *Objectives*

In this second main part of the paper we shall describe the process of developing a multi-perspective account of safety (MUPSY). MUPSY forms the backbone of a Practitioners' guide to learning from successful operations (Rosness et al. 2016a).

The primary purpose of MUPSY is to sensitise the user to actions, patterns of interaction and practices that contribute to successful operations. We saw this as a first step towards learning from successful operations. We may think of sensitisation in terms of building a pre-understanding that disposes people to detect events and patterns that they can connect with maintaining and improving safety.

We expected MUPSY to be used as a support for reflection and discussion in settings such as brief and informal talks, debriefs, job planning meetings, safety meetings and workshops. MUPSY is intended to supplement rather than replace traditional safety management tools such as system audits. We wanted to draw attention to issues that are not addressed by customary tools. We did not expect the account to be used in a tick-off manner for safety audits, nor did we expect the whole or parts to be integrated in formal prescriptions such as procedures and safety rules.

3.2 *Approach*

The development of a sensitising model entails several design choices (Le Coze 2013). The following are some of the choices we made for MUPSY:

We sought to emphasise the *diversity of perspectives* that can be used to identify contributions to safe operations. The theoretical basis for MUPSY is therefore formed by six different perspectives on organisational safety and resilience, i.e., energy and barriers, information processing, Normal Accidents, High Reliability Organisations, conflicting objectives, and resilience engineering (Rosness et al. 2010, 2016b). No attempt was made to combine or reduce these perspectives into a single concept such as "informed culture" (Reason 1997) or "mindfulness" (Weick & Sutcliffe 2001).

We sought to *bridge the systemic/organisational level and meso/micro level* (group interaction and individual actions) in an explicit manner, using straightforward arguments in everyday language about means and ends. For instance, we argued, based on the findings of Turner, that "safety is built by every action and practice that helps the organisation collect, share and interpret information about how accidents may occur and how they can be prevented" (organisation level). We then argued that because many accidents start at organisational boundaries, bridging across all those interfaces is an important contribution to safe performance (link to meso/micro level).

We sought a format that *allows users to extend the model* based on their own observations. We did not seek to develop a complete and closed model encompassing all or nearly all actions, patterns of interaction and practices that may contribute to safe operations. This is in contrast to, e.g. the Management Oversight and Risk Tree (MORT; Johnson 1980) which is intended to give a nearly complete coverage of the management controls needed to handle hazardous technologies.

We *did not want to dichotomise or rate performance* into categories such as "adequate/less than adequate" or "failure/success". Since the objective was not to build an audit tool or a rating tool, we felt that such dichotomies could impose an unwanted simplification. Such dichotomies are often constructed post hoc, after the occurrence of an unwanted event (Dekker 2011). The people performing work are not always in a position to make such distinctions in an unambiguous manner.

3.3 *Outline of MUPSY*

The two-level structure of MUPSY is shown in Table 1. The top level (Column 2) comprises seven high level tasks and a more open category ("What happens when nothing happens?"). These can be mapped to six different perspectives on organisational accidents and resilient organisations (Column 1). The second level (Column 3) comprises actions, patterns of interaction and practices that may contribute to the accomplishment of the high-level tasks. Thus, the high-level task "ensure adequate barriers against unwanted event sequences" corresponds to the barrier and energy perspective on organisational safety. Actions, patterns of interaction and practices that may contribute to the high-level task include "ensure that sufficient barriers are in place", "testing and checking barriers" and "ensure that barriers are independent".

Each item at second level is explained if necessary, and illustrated by one or more examples.

Table 1. The two-level structure of MUPSY.

Perspective	High-level tasks	Relevant actions, patterns of interaction and practices
Barrier and energy perspective	Ensure adequate barriers against unwanted event sequences	Ensure that sufficient barriers are in place Testing og checking barriers Ensure that barriers are independent
Information processing perspective	Ensure adequate sharing and interpretation of information	Share information across the boundaries of the organisations Challenge the prevailing understanding of the situation Providing space and time for slow discussion and slow thinking Anti-scapegoating
Normal accident theory	Handle complex and hot-tempered technologies and operations	Loosen tight couplings Reduce interactive complexity Strengthen coordination to handle tight coupling Prepare to handle complex and tightly coupled system states Adapt the informal organisational structure to the situation
High reliability organisations	Use organisational redundancy to ensure safe operation	Seek advice or a second opinion Offer assistance or advice to co-workers Intervene when somebody makes a slip or mistake Double check plans and decisions Utilise information technology to build redundancy
Conflicting objectives: Risk taking, adaptation and drift	Ensure safety in the face of conflicting objectives	Keeping tasks in reserve in order to avoid downtime Take a timeout Communicating about priorities, making conflicting goals explicit Ensuring a good decision process, reaching a conclusion in an orderly manner Provide stop rules Change the economic trade-offs for a contractor in favour of safety Distinguish between urgent and not so urgent safety issues
Resilience engineering	Handle minor disruptions	Finding ways to get around problems Recognising patterns based on experience Surprise handling Deciding to abort a job
	Prepare for a nasty surprise	Managing the unexpected Expansion of expectancies Meeting variation with variation
	What happens when nothing happens?	Create and maintain conditions that are necessary to carry out work safely Reflect on everyday practices that keep operations on track under varying conditions Monitor that which can become a threat in the near term

The item "offer assistance or advice to co-workers" is, for instance, explained as follows:

You can also build organisational redundancy by offering assistance or advice to a colleague. The item is illustrated by the following example:

Air traffic controllers sometimes compensate for high traffic load by assisting each other. When traffic is particularly intense at one workstation (radar console), a third controller silently joins the two who are coordinating the sector. The third controller provides "an extra pair of eyes" and helps to detect potentially dangerous situations. He or she may provide suggestions, usually in the form of questions rather than directives.

This example may also sensitise the user to significant details concerning *how* second-level tasks are accomplished. Providing suggestions in the form of questions can have an impact that is different from giving directives.

The heading "Relevant actions, patterns of interaction and practices" was chosen to sensitise the user to three different manners in which the high-level tasks are accomplished. In some cases, a single action makes a difference, for instance somebody challenging the prevailing understanding of a situation. In other cases, patterns of interaction are crucial, for instance, when people in a drilling crew demonstrate a willingness to share responsibility and avoid scapegoating after an incident ("anti-scapegoating"), and thus help to build a culture where people can share bad news with the confidence that it will not be turned against themselves or their fellow workers. Finally, a high level task may be accomplished through recurrent practices, for instance the performance of a formation integrity test at certain stages in the drilling of an oil well.

Taken together, the two task levels and the examples provide the user with an account of safety work at three different abstraction levels. Presenting an account of safety at several levels is part of our sensitising strategy.

3.4 *Intended use: Learning from successful operations*

The most salient vehicle for learning in large organisations is perhaps formal management systems. Procedures and other governing documents are revised, added or expanded, in order to accommodate new insights and turn them into prescribed practices. This process is often driven by negative experiences. Procedures are added or tightened in response to unwanted incidents.

This mechanism of learning is attractive for several reasons. The learning process is explicit and traceable, the visible costs are usually small compared to e.g. technical modifications, the change can be made immediately applicable to the whole organisation, and it can be followed up through audits. There are, however, important limitations. There is a limit to how much a management system can grow before it becomes unpractical—either because people are no longer able to keep track of their obligations, because they do not have the capacity (e.g. time) to fulfil all the demands made by the management system, or because the format of written procedures is not sufficiently flexible to adapt to the changing contingencies people meet when they do their job (Nathanael & Marmaras 2008). There is also a limit to how much time managers can spend focussing on complying with rules and checking the compliance of their subordinates before it significantly reduces their time and scope for reflection on safety issues.

Based on these considerations, we explicitly warn against integrating the MUPSY account of safety work as a whole (or major parts) in management system or procedures. As an alternative, we encourage reflection on the less visible aspects of safety work and on the preconditions for such safety work. Putting into words how certain practices contribute to safety without freezing them into procedures can give them legitimation and recognition without locking them into a format that is inappropriate to flexibility demands of many work situations. We see a significant potential for positive effects if management is included in the discussions and workshops, as the guide may help making visible across organisational levels the adaptive practices that contribute to successful operations, and give basis for establishing mutually agreed limits of adaptations (Grøtan et al. 2016). The Practitioners' guide to learning from successful operations (Rosness et al. 2016a) therefore provides explicit advice on preparing short discussions, workshops, debriefing and observations. The guide also gives advice on how to learn from successful recovery in conjunction with critical incidents.

4 DISCUSSION

4.1 *The visibility of safety work*

One way of understanding what Turner labels 'the incubation phase'—where the future is not determined but where one after an accident is likely to find a building-up of inadequate interpretations and decisions—is as a phase of unsensational operations where cultural conditions make some aspects visible and other invisible. Both from Weick's (1987) demonstrations that «making meaning is an issue of culture, which is one reason culture is important in high reliability systems» and Goodwin's (1994) elaboration on professional vision, we know that seeing as well as sensemaking is a cultural activity (Haavik et al., in press). Operationalised into safety culture, what we see and which meaning we associate with it is closely depending on "shared and learned meanings, experiences and interpretations of work and safety" (Richter & Koch 2004).

Acknowledging this makes it possible to elaborate on WYLFIWYF as a key to expand what may be found—or seen. By paying particular attention to the first part of the acronym—*what you look for*—one may actively influence *what you find*. This is exactly what MUPSY addresses: to help identifying the practices that make the difference between an incubation phase and a phase of successful work, and to be able to identify this in real time instead of post hoc. MUPSY is a qualitative tool for informing and expanding the pre-understanding of those performing or observing work, and to help interpreting what is going on. Although it is developed without explicit references to safety culture, the dominating definitions of safety culture nevertheless could make MUPSY relevant also from that perspective.

4.2 *Making safety work visible*

We propose that the notion of preunderstanding captured by the WYLFIWYF acronym can be used as a starting point for making safety work visible. Our multi-perspective account of safety is built around six different perspectives on organisational accidents and resilient organisations. Each perspective introduces a complementary preunderstanding of the things people do to prevent accidents. Although the "WYLFIWYF mechanism" is still operative, it is less restricting if you are able to change perspective ("What you look for"), and thus look for different patterns and phenomena.

A second means for making safety work visible is the use of three different abstraction levels, i.e. (1) high-level tasks, (2) actions, patterns of interaction and practices, and (3) concrete examples. The high-level tasks provide broad perspectives, whereas the lower level items provide specific, more easily recognisable instances of things people do to build safety. The high-level tasks alone might prove too abstract to help people immediately recognise relevant actions, patterns of interaction and practices. The third level, concrete examples, may give additional help in detecting instances of an action, patterns of interaction or practice.

It should be recognised that the lists of second level items never will be complete. The high-level tasks therefore serve as an invitation to the user to look for additional relevant actions, patterns of interaction and practices. They also help to structure the over-all account of safety and make it transparent.

4.3 *Learning from successful operations*

MUPSY was devised to serve as the backbone of a *Practitioners' guide to learning from successful operations*. We provide suggestions on how to use the account as a help in arranging short discussions, workshops and to support observation work. We explicitly warn against integrating the account as a whole in management system or procedures, as this would contribute to an inflation of rules and procedures, which is already a problem in many enterprises. However, we see a significant potential for positive effects if management is included in the discussions and workshops, as the guide may help making visible across organisational levels the adaptive practices that contribute to successful operations, and give basis for establishing mutually agreed limits of adaptations.

4.4 *Functionalist explanations versus hermeneutical approaches*

Functionalist explanations, focusing on prediction and manipulation, are often seen as incompatible with hermeneutical approaches focusing on understanding. It is fair to say that safety science as a whole is somewhat marked by positivist perspectives, and that functionalist explanations have had a stronger influence than hermeneutical ones. Reason (1997) for instance, refers to safety culture as something to be engineered, rather than something to be understood. While intentions are good, findings from grounded theory inspired research sometimes are coarsely exploited in deductive, causal explanations.

We do not claim that our perspective solves the problem of managing the relation between functionalist explanation and hermeneutical approaches (interpretative description) in safety science like cutting off a Gordian knot, but it offers a pragmatic stance to this relation. What we suggest is that theories and models should be seen, not as stable tools reflecting causal relations, but as platforms or discourses for doing and communicating research into the particular, the only place in time and space where knowledge really comes close to 'truth'.

It is in debt to such an epistemology we have developed our 'explanation' of 'anti-scapegoating' as a practice that holds the function of ensuring openness of communication in organisations, and that may be seen as one of many types of practices that help organisations ensure adequate sharing and interpretation of information. MUPSY is filled with claims concerning the functions of specific actions, patterns of interaction and practices with regard to safety. However, this 'functionalist style' is compatible with our everyday efforts to interpret and make sense of human action in terms of goals and means.

4.5 *Limitations and need for further work*

MUPSY is now available as part of a Practitioners' guide to learning from successful operations (Rosness et al. 2016a). The guide as such has not yet been tested in a practical setting. However, the proposed approach for planning and conducting a workshop is based on our own positive experience with a case based workshop focusing on one of the six perspectives of MUPSY ("Ensure safety in the face of conflicting objectives"; Størseth et al. 2010, Rosness et al. 2016a). The proposed analysis approach for successful recovery has been successfully used as a group task in an accident investigation course for an oil company. A possible obstacle against the acceptance and use of the Practitioners' guide is the fact that the absence of accidents does not in general force companies and their managers to act. Putting MUPSY into work would put the ideas proposed in this paper to an effective practical test.

We refer to MUPSY as an *account* of safety work. This terminology was chosen to avoid any claim that MUPSY is a falsifiable theory in a rigorous sense. MUPSY does claim that specific actions, patterns of interaction and practices help to build safety. However, it seems doubtful whether these claims can be converted into a set of hypotheses that is easily testable in practice. One reason for this is that the potential number of such hypotheses is very large whereas accidents and serious incidents that might serve as a dependent variable are rare occurrences in most systems.

MUPSY is designed to be open-ended and incomplete. It will always be possible to introduce another perspective, i.e. another high-level task. For any given high-level task, it will also be possible to think of additional actions, patterns of interaction and practices that contribute to the accomplishment of the high-level task. We think of this open-endedness as an asset rather than a limitation, because it gives the users room for deeper reflection on how safety is created. A possible further development is to expand MUPSY by integrating one or more perspectives as high-level tasks with accompanying actions, patterns of interaction and practices.

5 CONCLUSIONS

We have argued that safety work, i.e. the things people do to prevent accidents, is partially invisible, sometimes even to the actors themselves. We propose that people may be sensitised to some of these tacit aspects of safety work by providing them with a richer pre-understanding of the things they do to prevent accidents. Our multi-perspective account of safety (MUPSY) therefore utilises six different perspectives on organisational safety to sensitise the users to the different ways in which individuals, groups and organisations build safety.

Although it may be technically possible to integrate large parts of MUPSY in procedures and other governing documents, we do not recommend this approach. Administrative systems may grow to a point where they become unpractical. As an alternative, we encourage reflection on the less visible aspects of safety work and on the preconditions for these.

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Influence of temperature and surroundings humidity on scaffolding work comfort

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ABSTRACT: The article presents outcomes of environmental parameters studies made on scaffoldings. For this purpose, air temperature and relative humidity were used. Unfavorable environmental conditions can affect the behavior of people working on scaffoldings, resulting among others in tiredness and reduced reaction time. This increases the risk of dangerous situations occurrence. Therefore it is important to show what kind of climate changes the worker is exposed to. Outcomes are presented for three scaffoldings located in Lodz, Warsaw and Wroclaw. Air temperature and relative humidity varied depending on both the time of the day and the height of the working level on which the measurements were made. Air temperature in most cases was increasing, while the humidity was decreasing. Analysis have shown that users are exposed to highly variable climatic conditions, which are difficult to adapt in the short term, and heat discomfort caused primarily by high temperatures.

1 INTRODUCTION

Handling of construction works at altitude and in inaccessible locations is the basic use of construction scaffoldings. Very often scaffoldings are structures with complicated geometry and because of economic reasons there are assembled with as small amount of slender elements as possible. The consequence of this is low stiffness of the construction which is not user friendly.

This leads to undesirable dangerous situations including for example: accidents of assemblers, accidents of users—workers doing their work on scaffoldings, accidents of people in danger zone and consequently even construction disasters. The average cost of a serious accident which the company must incur is 213470 PLN, when the preventive measures cost which would prevent the accident is 1712 PLN. This is much lower cost compared to the cost of an accident (Hola et al., 2016). For example, a studies made on 62 scaffoldings in the Great Britain showed that 6.4% of accidents were caused by human mistakes (Whitaker et al., 2003).

An accident or construction disaster can occur at every stage of the scaffolding operation, during assembly, exploitation and dismantling (Błazik-Borowa & Szer 2016).

Therefore it is very important to ensure optimum working conditions on the scaffoldings and their surroundings. Examinations has shown (Traczyk et al. 2004) that the optimum temperature ranges from 18°C to 21°C and the relative humidity should be in the range from 40% to 70%. Wherein the increase of relative humidity by 10% is felt similar to the increase of operational temperature by 0.3. During assessment of thermal conditions is taken into account not only the frequency of high temperatures, but also the frequency of unfavorable differences between the minimum and maximum temperatures. Temperature changes are strongly felt if they are from 8.0°C to 11.9°C. As a severe are called changes exceeding 12°C. (Błażejczyk & Kunert 2011). In the United States, researchers have shown that the negative impact, according to the Web Bulb Globe Tempe-rature indicator (WBGT), is noticeable in case of light work above about 29°C for workers without acclimatization, and for workers who had been acclimatised at around 32°C (Hancock & Vasmatzidis 1998). The temperature value with negative influence varies depending on the length of the task and the type of task.

It should also be taken into consideration that working safety, apart from thermal conditions, is also influenced by other factors (Błazik et al. 2015), which may contribute to deterioration of health and well-being (Jia et al. 2016).

This article presents results of two selected environmental parameters measurements that affect scaffoldings users comfort, it means humidity and air temperature.

2 SCAFFOLDINGS EXAMINATIONS

Construction scaffoldings examinations are conducted by five teams from the Faculty of Civil Engineering and Architecture of the Lublin University of Technology, Faculty of Management of the Lublin University of Technology, Faculty of Construction, Architecture and Environmental Engineering of the Lodz University of Technology and the Faculty of Civil Engineering and Water Engineering of the Wroclaw University of Technology. The research covers frame, façade construction scaffoldings with a minimum area of 50 m^2. Scaffoldings are located in different parts of Poland. In total during years 2016–2018 research will cover 120 scaffoldings together with their users on construction sites (Hola et al. 2016).

Each scaffolding is covered by one working week long study and during this time are collected both information about scaffolding and its surroundings.

Measurements results which are presented in the article were made for three selected scaffoldings. Analyzed scaffoldings were chosen based on wind measurements. It was important to choose those with the smallest wind influence (on these scaffoldings wind speed was the smallest). The scaffolding marked E04 was located in Lodz and was examined from 15 to 30 of July 2016. W08 scaffolding was located in Warsaw and was studied from 4 to 9 of September 2016 and D08 scaffolding was located in Wroclaw and examined from 12 to 16 of September 2016.

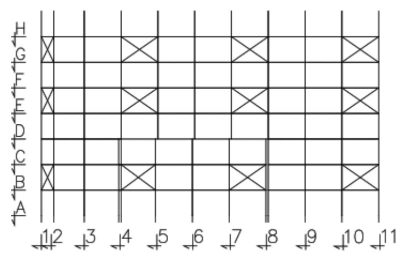
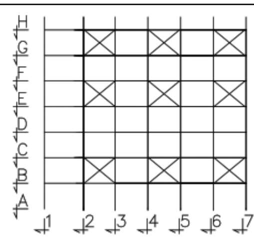
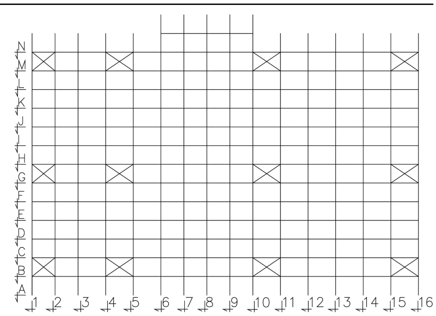
3 ENVIRONMENTAL PARAMETERS STUDIES

The following environmental parameters are examined on the scaffoldings: air temperature, relative humidity, atmospheric pressure, light intensity, wind velocity, sound level and dustiness (Błazik-Borowa & Szer 2016). This article presents selected parameters: air temperature and relative humidity.

Series of measurements on the scaffolding was performed through five days a week from Monday to Friday during the working hours of the workers (use of the scaffolding) in repeating intervals of time at. 8.00 a.m., 11.00 a.m. and 2.00 p.m., on different levels of scaffolding. This series of measurements last about an hour and depended on the number of measurement points.

Measurements of environmental parameters were performed in four, six, nine or twelve places on the scaffolding. The number of measurement points on the working platform depended on the number of scaffolding fields and on availability—for one field it was one research point, for two to four fields—two research points located in the extreme fields of the scaffolding, for five to eight scaffolding fields—three research points located in the extreme fields of the scaffolding and in the middle field, and for nine or more scaffolding fields, there were four research points located in the extreme fields of the scaffolding and two located in the middle of the scaffolding. The number of examined working levels depended on the height of the scaffolding. For scaffolding height from two to four meters, what corresponds to one or two working levels, one level of scaffolding was examined, from six to ten meters, two levels of scaffolding were examined located at the lowest and the highest altitude, and for more than 12 meters, what corresponds to six working levels, studies were conducted on three working levels located at the lowest, middle and the highest altitude of scaffolding. Scaffoldings schemes, together with examined points, are indicated in Table 1.

Table 1. Schemes of scaffoldings.

Symbol	Scheme of scaffolding
E04	
W08	
D08	

E04 scaffolding, 27.5 m wide and 16.0 m high, was mounted on the south-west side facade of renovating office building. The scaffolding assembly was made on the basis of the Rux scaffolding systems manufacturer's catalog. W08 scaffolding, 16.4 m wide and 15.0 m height was located on the north-west side facade of residential and office building. It was a frame scaffolding, which was assembled on the basis of Altrad Mostostal manufacturer's catalog, while D08 scaffolding 43.0 m width and 30.0 m height was located on the west side facade of service and residential building. Assembling of this scaffolding was made in the Blitz system, also on the basis of Layher manufacturer's catalog. All scaffoldings were secured by handrails and toe boards. All scaffoldings surfaces were exposed to direct sunlight. However, on E04 and W04 scaffoldings, insolation was smaller due to mounting a safety nets in order to protect pedestrians from the possibility of falling tools hit.

4 MEASUREMENT DEVICES

Measurements were made using AMI310 multi-function device, with connected climate module that records temperature and humidity. Measurement range of temperature probe was from –10°C to 45°C with 0.1°C sampling, while the humidity probe measurement range was from 0 to 100% with 0.1% sampling. Measurement time at one measurement point was 4 minutes.

5 RESULTS

Minimal and maximal values of air temperature and relative humidity are presented in Tables 2–3. In the fourth column there is average value of air temperature and relative humidity calculated for five day measurement made on scaffoldings.

Table 2. Air temperature.

Scaffold symbol	Minimal temperature [°C]	Maximal temperature [°C]	Average temperature [°C]
E04	20.6	37.4	27.2
W08	17.7	32.1	24.7
D08	17.7	42.5	27.6

Table 3. Relative humidity.

Scaffold symbol	Minimal humidity [%]	Maximal humidity [%]	Average humidity [%]
E04	30.3	84.3	55.2
W08	33.6	91.9	55.3
D08	14.1	71.4	41.3

In case of air temperature the highest change of this parameter equals 24.8°C and was noticed at D08 scaffolding. The highest change of relative humidity value equals 58.3% and was noticed at W08 scaffold.

Diagrams showing changes of air temperature depending on the level, which were obtained for every analysed week day during measurements starting at 8:00 a.m., 11:00 a.m. and 2:00 p.m., are presented on Figs. 1–3. Results are displayed for average

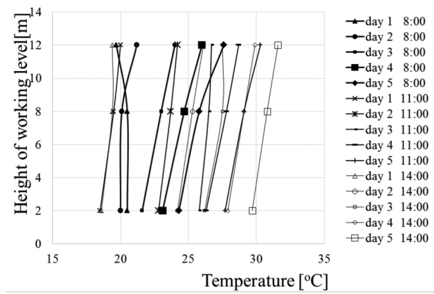


Figure 1. Measurements results of temperature on scaffolding for E04.

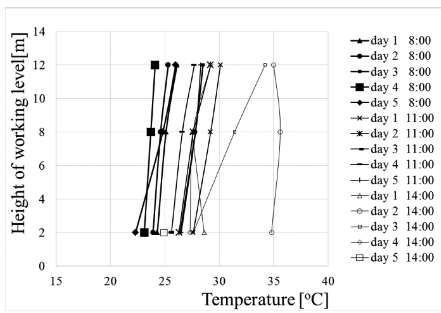


Figure 2. Measurements results of temperature on scaffolding for W08.

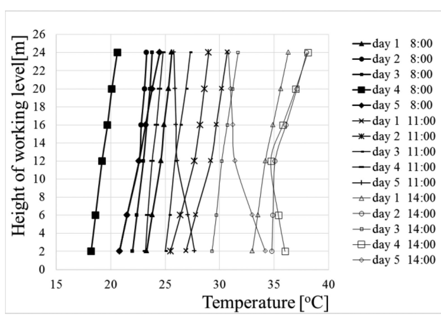


Figure 3. Measurements results of temperature on scaffolding for D08.

values measured during four-minute long measurement on three scaffoldings E04, W08 and D08.

Following diagrams (Figs. 4–6) show results of air relative humidity measurements depending on level for every 5 week days starting at 8:00 a.m., 11:00 a.m. and 2:00 p.m. Results are displayed for average values measured during four-minute long measurement at mentioned three scaffoldings.

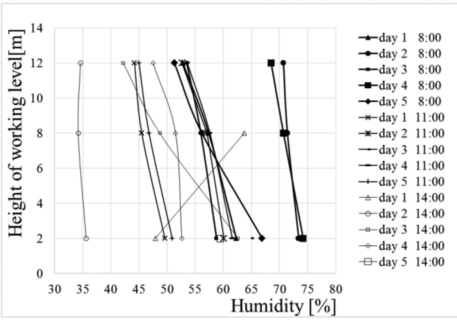


Figure 4. Measurements results of humidity on scaffolding for E04.

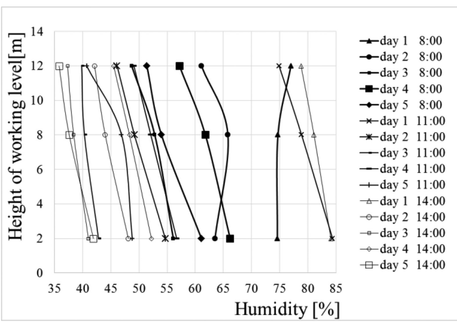


Figure 5. Measurements results of humidity on scaffolding for W08.

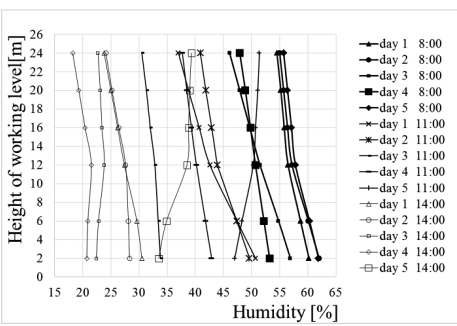


Figure 6. Measurements results of humidity on scaffolding for D08.

Both, air temperature and relative humidity were changing in dependence on time of the day and height of working level, where measurements were taken. In most cases air temperature was increasing, whereas humidity was decreasing. The greatest temperature escalation in conjunction with height equals 6.6°C occurred for E04 scaffold during third day at 2:00 p.m. The greatest humidity drop in conjunction with height equal 20.4% was noticed at the same day and time. It can also be noted that value of air temperature decreases because of weather conditions change (e.g. precipitation appearance) which has also impact on humidity diagram.

6 RESULTS ANALYSIS

Even bigger changes of air temperature and relative humidity are noticed by analysing minimal and maximal values measured during whole day from 8:00 a.m. to 3:00 p.m. In tables below, there are presented changes of air temperature between minimal and maximal value measured during one day for all week days (Table 4).

Average value of air temperature changes during one day on E04 scaffold for all week days come to 9.7°C ranging from 8.0°C to 14.1°C. In W08 scaffold case average daily air temperature change least equals 3.8°C ranging from 2.5°C to 4.8°C. For D08 scaffolding it was 17.6°C ranging from 9.3°C to 24.8°C.

Taking into consideration amount of days, when there was highly perceptible air temperature change, it is 2 days for both, E04 and D08. Workers on E04 scaffolding were exposed for acute air tem-

Table 4. Changes of air temperature.

	E04 [°C]	W08 [°C]	D08 [°C]
Day 1	7.6	2.5	15.6
Day 2	14.1	4.1	9.3
Day 3	11.3	2.7	11.6
Day 4	7.7	4.8	24.8
Day 5	8.0	5.2	16.8

Table 5. Changes of relative humidity.

	E04 [%]	W08 [%]	D08 [%]
Day 1	32.1	19.7	47.1
Day 2	54.0	24.6	50.5
Day 3	36.6	13.3	41.9
Day 4	31.9	17.6	47.9
Day 5	30.3	28.5	41.7

perature changes during one day and in D08 scaffolding case it was three working days.

Table 5 shows changes of relative humidity for the same measurements conditions as in case of air temperature study.

In case of relative humidity average value of change during one measuring day for E04 scaffolding equals 37.0% ranging from 30.3% to 36.6%. Average daily relative humidity change for W08 scaffolding equals 20.7% ranging from 13.3% to 28.5%. The greatest average value of relative humidity daily change, same as in case of air temperature, was noticed for D08 scaffolding and equal 45.8% ranging from 41.7% to 50.5%. Changes of air temperature and relative humidity are much higher for D08 scaffolding than in case of remaining scaffoldings. Location in relation to world directions wasn't the reason of obtained results, because all of the scaffoldings were situated totally or in part to the west side. However, it can be noticed, that this scaffolding is much higher than the remaining two, and probably that's the main reason of measurements differences. There is also another factor—lack of protective net which expose workers for much worse conditions.

Taking into consideration fact, that the relative humidity change over 10% increases change of air temperature, it can turn out that the amount of days when highly perceptible or acute air temperature changes appear can be definitely higher.

7 CONCLUSIONS

Construction workers doing their job on scaffoldings often perform work associated with physical effort. Moreover they are often working on significant height. That is the reason why working on scaffolding is associated with high risk level of occurring dangerous incidents. Unfavourable environmental conditions can additionally influence on work comfort decrease. Monitoring of climatic parameters in that case is important.

On the basis of presented researches, it can be said, that scaffolding users are exposed to highly variable climatic conditions, which are difficult to adapt in the short term, and heat discomfort caused primarily by high temperatures

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Two different qualitative cyberneticians: Barry Turner and Jens Rasmussen

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ABSTRACT: Both Barry Turner and Jens Rasmussen were qualitative authors with a keen interest in the study of real life situations beyond the experimental traditions of science. But if the former knew, endorsed and applied grounded theory, the latter did not. They shared nevertheless, as trained engineers turned into respectively a sociologist and a cognitive engineer, a cybernetics background which considerably shaped their qualitative mindsets. In the paper we discuss how it influenced their understanding and interpretation of the role played by humans in accident disaster causation. A final section of the paper discusses some of the similarities and differences in the approaches adopted by Turner and Rasmussen, in particular the relationship between the conceptual and the empirical when studying phenomena. Turner was more into describing while Rasmussen into prescribing, and although both of them were engineers, our analysis reveals some important similarities and differences in their respective worldviews.

1 INTRODUCTION

Over the course of the mid-1970s through to 2000, the organizational sociologist Barry Turner (1937–1995) made some of the most important theoretical and methodological contributions to the field of safety science. Turner worked against the background of a number of other important developments within human factors/ergonomics, safety science and other disciplines (e.g., the work of James Reason, Charles Perrow, Karl Weick and Aaron Wildavsky on human error, disaster and accident causation). In this paper we focus on the aspects of Turner's work which were influenced by previous work on cybernetics and systems theory, as well as the influence these had on Turner's work on the theory and development of qualitative methods (e.g., Grounded Theory). In order to reflect on Turner's qualitative practice and his contribution to the topics of safety culture and organizational learning following disaster (Turner and Pidgeon, 1997), we compare and contrast his work with another pioneer of safety research, Jens Rasmussen (b.1926). We believe that these two major authors had two distinct but in many ways synergistic ways with which they approached the qualitative analysis of safety research in the 1970s, 1980s and 1990s, as well as the influence cybernetics had on their work.

2 CYBERNETICS—A BRIEF OVERVIEW

The term 'cybernetics' was first coined by the mathematician Norbert Wiener in 1947 and defined as "the scientific study of control and communication in the animal and the machine" (Wiener, 1948). Emerging out of Second World War research on servo-mechanisms and control systems, cybernetics offered a transdisciplinary approach (e.g., drawing on psychiatry, early forms of computing machines, psychology and physiology) which could be applied to applied to a range of problems and challenges involving automation, cognition and decision-making and organizational behavior (Pickering, 2011; Pid, 2016). In the 1970s, new cyberneticians emerged in multiple fields (so-called 'second order cybernetics'), but especially within biology, information and computer science, and engineering. Work by such figures as Gregory Bateson (1904–1980) and Gordon Pask (1928–1996) for example, shaped the course of many aspects of current day thinking in fields such as anthropology, psychiatry and medicine, education and computer-based learning.

3 BARRY TURNER AND CYBERNETICS

Throughout the course of Turner's work, whether the focus was on organizational symbolism

(Turner, 1986), qualitative research methodology and in particular grounded theory (Turner, 1981, 1983, Martin, Turner, 1986, Gherardi and Turner, 1987, Turner, 1988) or the origins of disaster (Turner, 1978; Turner and Pidgeon, 1997), it is possible to discern the explicit influence of cybernetic concepts and constructs. Part of the appeal of cybernetics to Turner may have been that it provided a set of different 'lenses' drawn from different disciplines which could then be used to build up a set of over-lapping accounts of the phenomenon under-investigation (e.g., the Aberfan disaster—Turner 1978; Weick, 1998). Turner himself used a similar metaphor ('shaking a kaleidoscope'—Turner, 1995: 283) to describe his approach towards scholarship. In what follows, we focus on four main ways in which Turner introduced cybernetic ideas into his work.

3.1 *Complex systems and 'natural history'*

One particular role that was adopted by Turner in his analysis of accidents and complex systems was that of the 'natural historian':

> *"The natural historian interacts with an external system at many levels and in many ways … from a systems point of view, the natural historian is one multi-faceted, complex system and the adjacent environment is another"* (Turner, 1995:227).

The idea that natural history might be useful metaphor for his work was one that Turner derived from the work of the cybernetician Gordon Pask on 'the natural history of networks' (Pask, 1960). Pask's work on self-organizing systems emphasized the need to keep an open mind about the nature of cause and effect and the behavioral characteristics of systems (e.g., models of human motor control and decision-making). Rather than seek out 'absolute truths' about these systems, the goal was to use data collection to capture *'a particular constellation of information and experiences'* (Turner, ibid.) which might shed further light on how systems function. Similarly, in earlier work, Turner (1988) makes use of the verb *'to botanize'* to describe how he analyzed disasters in order to *'sort out and name the social flora and fauna to be found in the setting'* (Turner, 1988:109).

3.2 *Negentropy, 'Anti-tasks' and amplification of events*

A large part of Turner's legacy to safety science is the work he conducted on understanding how organizations miss signals that something can go wrong, but also had an interest in the "*unanticipated consequences of purposeful social action*" (Merton, 1936) Turner (1978; Turner and Pidgeon, 1997) argues that one consequence of systems complexity is that "*the more extensive a negentropic, order seeking system becomes, the greater the potential which it also develops the orderly dissemination of unintended consequences*" (Turner, Pidgeon, 1997, 150) Turner refers to these types of failure modes as '*anti-tasks*' (Turner and Pidgeon, 1997:150), a term which he partially derives from earlier research in second-order cybernetics. Maruyama (1963) for example (Turner and Pidgeon, 1997: note 25:224) discusses the influence of small deviations from the normal functioning of systems which can build up and mutually reinforce one another and influence their behavior. In other places *Man-Made Disasters* makes reference to other aspects of cybernetics, both in the original form and later second-order versions. Many of these references are linked to the question of how biological systems function and how they succeed or fail (e.g., references to information, energy and the thermodynamic properties of living organisms). At the heart of these parallels and references to cybernetics is a concern with what Turner calls their '*ontic status*' (Turner and Pidgeon, 1997: note 35:225). This might be interpreted as a concern to identify processes (e.g., anti-tasks in the incubation stage of disaster) which operate in the background of organizations or are somehow hidden from view (c.f. Reason's latent conditions for error—Reason, 1990), alongside processes which are more observable and easier to identify. This approach towards data collection and analysis as it relates to the analysis of failure is characterized by its thoroughness and meticulous attention to detail.

3.3 *Conversation theory and Grounded theory*

Aside from the 'natural history' aspects Gordon of Pask's influence, it also seems likely that Turner made use of Pask's work on 'Conversation theory', particularly as it applied to his qualitative work using grounded theory. Pask conceptualized human-machine interaction as a form of conversation, a dynamic process, in which the participants learn about each other. According to the theory social systems are symbolic, language-oriented systems where responses depend on one person's interpretation of another person's behavior, and where meanings are agreed through conversations (Pask, 1975). Part of the influence on Turner may have been the manner in which he applied a dialectical and iterative approach to what he termed the '*cycle of observation-analysis-theorizing*' (Turner, 1988: 110) towards social phenomena. More explicitly, Pask's version of cybernetics also emphasized the importance of constantly shifting between 'objective' and subjective' viewpoints of the world. This viewpoint is also acknowledged by Turner:

> *"Our lives, as much as our researches, are dialectic, a 'conversational' movement between subjectivity and objectivity as we put meaning into things."* Turner (1988:116)

Grounded Theory also helped Turner to construct a *'complex map of the social world'* which reflected its complexity and *'requisite variety'* (Turner, 1988, p. 119, note 5; Ashby, 1952). This structured the conceptual basis for a different account of accidents as compared to Charles Perrow's famous thesis of Normal Accidents, relying not on technological determinism but on the notion of incubation period, a concept itself rooted within a Kuhnian frame of analysis (Le Coze, 2015b, 2017b).

3.4 *Analysing and theorizing—a never ending process*

A continual emphasis within Turner's work, whether the focus is on disasters or the methodology of the social sciences, is that the process of data collection/analysis and later theory formation involves building up a set of skills. These skills are acquired by learning from examples and the general process of apprenticeship (Turner, 1988: 121). Likewise, his work is characterized by humility and modesty; qualities expressed by a number of other cyberneticians, particularly in terms of the recognition that research is always on-going and never reaches a conclusion. Bateson (1972), a key influence on Turner (see for example Gheradi and Turner, 1987: 18), argues that cybernetic systems are in a state of constant transformation and flux and that the idea of a 'final state' is illusionary. Similarly, Beer's work on the Viable System Model (Beer, 1989) which suggested that the VSM, alongside other models, is in need of constant revision and updating and is never 'finished'.

A similar trait that Turner shares with many cyberneticians is the view that knowledge is not only constantly evolving, but is also incomplete. Pickering (2011) for example, argues that cybernetics embraces an epistemology where knowledge is organic, dynamic and grounded in actual practice, rather than embodied in Cartesian ideas or constructs. In this way Turner's work anticipates other contemporary accounts which emphasize the value of inter-disciplinarity and the social construction of reality (e.g., Scott's 1998 work within policy studies and political science and Wears and Hunte's 2014 critique of research on patient safety).

4 JENS RASMUSSEN AND CYBERNETICS[1]

Like Turner, Rasmussen was clearly influenced by cybernetics. The broad range of topics that he investigated and developed, including man machine interface, human error, accident investigation or sociotechnical analysis relied on key cybernetics ideas such teleology, circular causality, self-organization, requisite variety and second order cybernetics epistemology. Teleology is another word for intentionality. To model (or understand) the behaviour of such systems requires introducing their purpose. Rasmussen was cognisant of this issue, which had to be substituted for the traditional scientific rationale:

> *"the alternative is to consider such systems as intentional systems, controlled in their response to external influence within their range of capability by their 'intention' to act derived from the individual value structure and internal goals. Prominent examples are humans and social systems"* (Rasmussen, 1985).

It is also on this principle that he criticised the idea of human reliability analysis, by stressing teleology:

> *"We have to consider that humans are not simply deterministic input-output devices but goal oriented creatures who actively select their goals and seek relevant information. The behaviour of human is teleological by nature"* (Rasmussen, 1983).

Rasmussen was also designing his models with the help of circular causality or feedback loop principles. From his focus on the micro with work situations when elaborating recommendations of interface displays, conceptualization human error to macro interests such as modeling sociotechnical systems or representing multidimensional causalities of accidents, circular causalities were introduced. They offered him ways of thinking the linkage between technological artefacts and humans but without conflating engineering and social feedback loops:

> *"In order for 'general system science' to be useful to the kind of analysis of the potential for systematic break down of large scale socio technical systems with adaptive features, the classical cybernetic modelling approach needs to be modified to include semantic and intentional aspects of human systems"* (Rasmussen, 1989).

Combined with circular causality is the notion of self-organization borrowed from Ashby:

[1] This section is extensively derived from a previous publication (Le Coze, 2017b).

"Systems with a high degree of autonomous internal functioning, with self-organising and adaptive features, may change their internal functional organisation frequently in order to meet the requirements of the environment and to suit their internal goals or performance criteria. Even though such systems are basically causal and controlled by the laws of nature, their complexity makes it impractical, if not impossible, to explain or predict their performance by functional analysis during real life decision making" (Rasmussen, 1985).

This important addition to his conceptual toolbox brings Rasmussen an analytical feature to model the notion of migration beyond the boundaries of safe performance. By coupling teleology, circular causality and self-organisation, one obtains a tight network of principles which explain unanticipated outcomes.

Finally, second order cybernetics offered him the possibility of introducing the observer and the subjectivity into different aspects such as design or accident investigation purposes. Second order cybernetics was indeed about the science of the observer, namely the need to consider from which perspective a situation is observed and interacted with. This idea is particularly well expressed in the following quote:

"Identification of accidents causes is controlled by pragmatic, subjective stop rules which to a large extent also depend on the aim of the analysis, i.e. whether the aim is to explain the course of events, to allocate responsibility and blame, or to identify possible system improvements in order to avoid future accidents" (Rasmussen, 1988).

5 TWO CYBERNETICIANS WITH DIFFERENT PURPOSES

Turner and Rasmussen can be considered (but not exclusively) as cyberneticians, with a particular qualitative sensitivity. Although they were similarly influenced by the cybernetics moment, they borrowed ideas from different authors which reveal interesting sides to their work. Turner selection of Pasks' '*natural history of complex systems*' or of a '*conversation analysis*' is of way of stressing the epistemologically situated and dialectical relationship between an interpreter and a situation, in a cycle of never ending subjective and objective elaborations. This addresses one issue concerning the degree to which one can or should start with an explicit conceptual background when investigating social phenomena. Consistent with one of the underlying statement of grounded theory, Turner stresses that one should be especially careful in not expecting to frame beforehand a collection of data.

By contrast, Rasmussen defended the opposite thesis, alongside combining this with an engineering mindset (Le Coze, 2017b). He did not hesitate indeed to oppose the kind of description offered by Turner and other advocates of grounded theory in order to argue the case for a more scientific approach:

"Results of field studies, consequently, are often only specified by the name of the system studied, such as 'power plant control room', 'steel rolling mill', and the subjects are identified in terms of their profession such as 'process operators'. Unless, however, the characteristics of the 'process' environment and of the process 'operators' can be explicitly formulated, the danger exists that the results will be judged narrative journalism rather than scientific investigations" (Rasmussen, 1992).

The two researchers indeed applied very different, but complementary methodological approaches towards complex work environments. Rasmussen developed a broad approach to the study of complex work environments and socio-technical systems, but one that involved the production of what we could call, perhaps, more 'formalized' principles than Turner, developing new ways of modelling self-adaptive complex systems and what might be characterized as 'normal error' or a specific interpretation of Perrow's 'normal accident', as Ashbyan (Le Coze, 2015b, 2017b, Waterson et al., 2017). Why was this the case? One obvious interpretation would be to locate their difference in their disciplinary backgrounds. Although they were both initially trained as engineers, Turner as a Chemical Engineer and Rasmussen as an Electrical Engineer, they moved into sociology for the former and psychology and cognitive science for the latter. So perhaps the sociologist was naturally more inclined to approach social life as a contingent, historical and constructed phenomena which required close attention to specificities and differentiates cases rather than theoretical developments. But this is not entirely convincing because strong system theoretical tendencies also exist in sociology. It is unlikely to be a fair summary of Turner's intellectual approach as revealed by the following quote.

"I aligned myself with Weber's extensive taxonomies and infinite arrays of possibilities rather than with the system building of either Marx or Parsons. The only systems that I found appealing were those of general systems theory, which themselves turned out to offer a content free schema which can be viewed from many vantage points" (Turner, 1995, 280).

Turner did not reject theory but theory had to come from a different process of interaction between data and concepts, as seen above with the rationale of '*conversation analysis*' of Gordon Pask, hence his appreciation of grounded theory, which was partly based on a rejection of the grand theory of Parsons. What about Rasmussen? Was he more driven by the scientific norm of experimenting as developed by an influential part of psychology so that any descriptions in reference to a specific situation would be dubious because of their lack of generality and testability? Here again, the situation is a bit more complex because Rasmussen precisely differed from this constraints of studying cognition experimentally. He is one of the key promoters of a naturalistic approach of cognition, which has managed over the past 20 years to exist as an accepted and valid mode of investigation, alternative to the experimental one. So Rasmussen was also very keen on paying attention to real life contexts beyond the constraints of the experimental settings and the need for reproducibility.

Perhaps that the reason for their different uses of cybernetics is to be found in their intention as researchers. Turner was more into the process of *describing* while Rasmussen was more into the process of *prescribing*. This difference in purpose led them to different epistemological positions. Rasmussen adopted an engineering epistemology which involved designing solutions to problems as argued by Kant (2017), as this quote shows:

> *"In considering the human data processor as a system component, it is necessary to describe mental processes in a frame of reference compatible with the decisions to be made by the interface designer"* (Rasmussen, 1980).

Models from Rasmussen's point of view, should serve as a basis for guiding designers or managers to apprehend phenomena in a way useful to their purposes, e.g. designing computer screens, remaining with the boundary of safety performance. Models, should be simple enough to be understandable while at the same time grasping essential features of what is relevant to take into account for a specific purpose. In addiiton, one can also find a search for simple analytical principles which offer a leverage to understand phenomena. This is not without reminding the scientist quest for rules that once applied to phenomena, allow its explanation and, beyond, its prediction. It is probably not foreign to the engineering epistemology either. One example of this is the use of self-organized principles coupled with the notion of the degree of freedom. Together, these two principles can offer a bridge between the micro and the macro (this is of course not without reminding the conceptualization of economists).

By contrast, Turner does not show signs of such intentions; Although he also had a propensity to conceptualise, as shown with the incubation model of disaster, it was mainly from a descriptive point of view. Although trained as an engineer too, Turner had however a different approach to the epistemology of engineering, questioning its rationality and stressing its uncertain nature, as it is made explicit in man-made disaster:

> *"the very large factors of safety commonly adopted in engineering may be separated (…) a true safety margin, plus a margin of ignorance, which covers a wide variety of unknowns."* (Turner and Pidgeon, 1997, 17).

In contrast to Turner, Rasmussen did not challenge engineering (Le Coze, 2015). Most likely, he never saw in engineering the inherent uncertainty that social sciences started to address and to reveal in empirical studies (Wynne, 1988, Pinch, 1991). This difference is interesting because it might indicate a major differing feature of their philosophical preconceptions about the limits of the human mind. While Rasmussen probably remains a rationalist, believing in the power of the human mind to understand and solve problems, Turner was probably more cautious about a strong version of rationality, and did not hesitate to challenge one of its most admired achievement, science and engineering. As argued elsewhere, Turner developed the Kuhnian view of the unexpected and the normality of accidents, while Rasmussen developed the Ashbyan one (Le Coze, 2017), revealing two different mindsets indeed. Their identification, selection and use of cybernetics concepts both shaped and reflected these mindsets.

6 SUMMARY AND CONCLUSIONS

In this brief summary of the influence of cybernetic ideas on Turner and Rasmussen and their subsequent work on accidents and human error we have pointed to a number of similarities and differences in their respective appropriation of cybernetic ideas, concepts and theory. Needless to say, much more could be written on this subject. Many of the differences can be traced back to their respective backgrounds which in turn influenced their worldviews and epistemological stances toward accidents, error and knowledge. Bothe made much use of the rich intellectual 'matrix' offered by cybernetics, however, we would argue that a key difference between the two researchers is captured by the distinction describing (a passive stance, Turner) and prescribing (a more active, design—oriented stance, Rasmussen). Further work focusing on further elaborating this distinction is planned by the authors as future work.

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"Tough Love": Unpacking the dynamics of Turner's stage 6 (cultural readjustment)

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ABSTRACT: This study examines the perceptions and attitudes of RAF personnel following the 2006 fatal loss of Nimrod XV230 and subsequent Public Inquiry. The main focus was "cultural readjustment" and organisational learning. Phase 1 was carried out in 2010–2011 (18-month aftermath following the Haddon-Cave report) and Phase 2 in 2016 using follow up interviews, focus groups, observations and document analysis. The results point to a number of *barriers* to change in the early days post-inquiry, including fear of litigation and risk aversion, a military culture of 'can-do', normalized rule-breaking and insufficient safety expertise. *Facilitators* include leadership and followership, publicity and training and an enhanced regulatory framework. Ongoing *disrupting factors* were identified that may make the organisation vulnerable e.g. churn of critical personnel. The study suggests that organisations settle into a new quasi-stationary equilibrium following disaster, which may provide the 'illusion' of safety through increased safety bureaucracy.

1 INTRODUCTION

Arguably one of the most seminal pieces work carried out in the field of safety science over the last 30 years is Barry Turner's (1978) book 'Man-Made Disasters'. As the title of the book suggests Turner proposed that organizational disasters should not be viewed as cataclysmic 'Acts of God' but as a 'type' of disaster which comes about as the result of ever complex processes and everyday interactions within socio-technical systems (Pidgeon & O'Leary 2000).

As well as the concept that industrial disasters can be 'man-made', the book also introduced the notion of *'Failure of Foresight',* that is that large-scale organizational accidents can have long incubation periods, during which early warning signs are either ignored or misunderstood. Crucially his research suggested that man-made disasters had preconditions, which were common to all disasters. Disasters are not caused by people or technical issues in isolation, but rather they arise by interactions between humans and elements of complex systems. As Macrae (2014) states "disasters are essentialy organised events. To occur, they typically require the systematic and prolonged neglect of warning signs and signals of danger". As a result, 'organisational ignorance' (Smithson 1989), 'organisational silence' (Morrison and Milliken 2000) and 'organisational blindness' (Hopkins 2005) can prevent an organisation from heeding valuable early warning signs that could prevent disaster.

Turner believed that it is the 'social distribution of knowledge' i.e. "shared beliefs, collective assumptions, cultural norms and patterns of communication across organisations" (Macrae 2014) that can define how safe an organisation they are. The 'sloppy management' (Turner 1994) of information and knowledge, that is failure to collect and interpret safety data across complex organisations, is often identified as a contributory factor to disaster. Despite the best efforts of those involved within safety-critical industries, he believed that the safe operation of technological systems can be subverted by the 'normal processes of organisational life'.

Turner's (1978) work became the catalyst for extensive research into the nature of system safety and accident causation e.g. Reason (1990/7), Vaughn (1996) Turner and Pidgeon (1997) Weick and Sutcliffe (2007) etc. Turner (1978) developed a stage model to describe the 'lifecycle' of organisational disasters. He carried out a study of 84 accidents in 1960s and 1970s and concluded that all accidents progress through the 6 stages outlined below:

1 Culturally accepted beliefs about the world; norms set out in Laws, SOPS, regulations.
2 Incubation period: accumulation of unnoticed events (Latent Failures) which are at odds with the accepted beliefs about hazards and the norms for avoiding them.
3 Precipitating event: degree of recognition of some Latent Failures; transformation of the general perceptions of Stage 2.
4 Onset: disaster, accident occurs; cultural collapse.
5 Rescue and salvage following accident; first stage adjustment—recognition of immediate post-collapse situation allows rescue/salvage to take place.

6 Cultural re-adjustment: following inquiry, beliefs and norms are adjusted to fit the newly gained understanding of the world.

As Rosenthal (1996) states in the foreword to the 2nd addition of Turner's book: "the strength of the model is in its clear-cut, firm statement of the factors which, in conjunction, make for the incubation of disaster and crisis: perceptual rigidities, information ambiguities, the disregard of rules and instructions, and, eventually, overconfidence and organizational arrogance…it is as simple as it is powerful".

Following Turner other models have followed e.g. Shrivastava *et al.* (1988) *Industrial Crises Model*, Toft and Reynolds (1997) *Systems Failure and Cultural Readjustment Model,* Ibrahim *et al*'s (2002) *Pre-condition Phase Model* and Aini and Razi's (2006) model based on ten phases, all of which show that disasters follow a sequential stage/phase development process. Hughes *et al.* (2010) analysed disasters in six different industries (space, shipping, aviation, mining, rail and nuclear) to produce a *Generic Disaster Pathway* model. The model maps the pathway of a disaster through four phases in relation to severity. Despite more recent work on stage models e.g. Elliot (2009), Turner's original 6-stage model still stands out because of its simplicity.

Turner (1978) provided a great deal of detail regarding disaster incubation and onset but had less to say about cultural readjustment. Pidgeon accepts this in the updated version of Turner's book stating "implicit in the original model then, is the assumption that such readjustment can and will take place typically as some form of organisational learning" (Turner & Pidgeon 1997). Organisational learning may be defined as "a cumulative, reflective and saturating process through which all personnel within organisations learn to understand and continually reinterpret the world in which they work by means of the organisational experiences to which they are exposed" (Toft and Reynolds 1997).

Elliott and Smith (2006) challenge Turner's (1978) implicit assumption that cultural readjustment automatically follows a crisis by examining the UK football industry's response to four crises that affected it between 1946 and 1989. They concluded that despite the high profile mass casualties, public inquiries and legislative reform, little cultural readjustment had taken place. This was in part due to what Wicks (2001) described as a 'mindset of invulnerability'. What is clear is that the increasing complexity of socio-technical systems has resulted in an expansive safety research tradition. Despite this, the pre-disaster, disaster and post-disaster literature is unbalanced with less emphasis placed on the post-disaster phases.

1.1 *Aims and objectives*

The first objective was to examine a recent disaster, the 2006 Nimrod Crash and interpret it through the lens of Turner's model focusing on Stage 6, cultural readjustment. The second objective was to reflect on the model in light of the data gathered and consider the implications for future work.

1.2 *Nimrod crash and Haddon-Cave inquiry*

On 2 September 2006, RAF Nimrod XV230 was on a routine mission over Helmand Province in Southern Afghanistan in support of NATO and Afghani ground forces, when she suffered a catastrophic mid-air fire, which led to the total loss of the aircraft and the death of all 14 personnel on board. The subsequent Public Inquiry carried out by Charles Haddon-Cave, QC was released after a 20-month investigation. The scale of the investigation was unprecedented in British military history. Haddon-Cave (2009) concluded that: "Financial pressures...drove a cascade of multifarious organisational changes...which led to a dilution of the airworthiness regime within the MOD and distraction from safety and airworthiness issues".

The Nimrod Review represented one of the biggest triggers for change within the RAF since the end of the Cold War. It set in motion a host organizational changes, which took place in the context of busy operational activity in Afghanistan and Libya at a time of defence cuts. The RAF continues to be busy operationally in the Middle East today. This study aims to examine the perceptions and attitudes of RAF personnel following the fatal loss of the Nimrod and the subsequent Public Inquiry. The main focus of the research will be surrounding the "cultural re-adjustment" of the organisation in light of previous research e.g. Turner (1978); Birkland (2009) barriers and facilitators; Dekker (2007) just culture and Elliott (2009) organizational memory and learning.

Haddon-Cave's subtitle to the 'Nimrod Review' was "A FAILURE OF LEADERSHIP, CULTURE AND PRIORITIES" which gives an insight into the report's candid assessment of the MOD's failings. The wide ranging inquiry outlined many similarities between the loss of the Nimrod and other catastrophic accidents such as the *Zebrugge Disaster* (1987), *King's Cross Fire* (1987), *The Marchioness* (1989), and *BP Texas City* (2005). The report highlighted the MOD's shortcomings including a failure to adhere to basic principles; a military airworthiness system that was not fit for purpose; a safety case regime that was ineffective and wasteful; an inadequate appreciation of the needs of aged aircraft; a series of weaknesses in the area of personnel; an unsatisfactory relationship between the

MOD and industry; an unacceptable procurement process leading to serial delays and cost-overruns and a safety culture that allowed business to eclipse airworthiness. There were 84 recommendations the most striking of which was for a new military airworthiness regime under the control of an independent Military Airworthiness Authority (MAA), "which is effective, relevant and understood, which properly addresses Risk to Life, and which drives new attitudes, behaviours, and a new Safety Culture" (Haddon-Cave 2009). The report made recommendations for a Safety Culture comprising of a *Reporting Culture, a Just Culture, a Flexible Culture, a Learning Culture, and a Questioning Culture.*

2 METHODS OF STUDY

A longitudinal study was carried out using a number of different research methods including participant observation, documentation analysis and participant interview. The interview phase of the study was carried out between May 2010 and Mar 2011 (Phase 1) and follow up interviews carried out Apr/May 2016 (Phase 2) at RAF Waddington, a frontline base in Lincolnshire.

2.1 *Participants*

Participants were all volunteers and were selected by the researcher from across the organisation. Purposive sampling was used to ensure that sufficient representation was provided across the range of trades and rank structure. The majority of the interviews were with personnel of Sergeant or higher rank where the impact of the Nimrod Report was thought most likely to be felt and with those personnel with a direct safety role. These therefore represent lower/middle management and above. For Phase 2, the precise definition of some of the participant roles had changed since 2011 however the majority of the interviewees were employed in very similar roles to the original interviewees. Four of the participants who were interviewed in 2011 had taken part in 2016.

2.2 *Phase 1*

During this time the researcher was employed in the RAF and worked at RAF Waddington. Having spent 24 years as an engineer working on a number of different aircraft types, the researcher was uniquely placed as a participant-observer to carry out an observational study of RAF Waddington's personnel. A total of 30 semi-structured interviews were carried out during Jan-Mar 2011. The researcher also observed reactions to the Haddon-Cave Inquiry at a large number of Aviation Safety Meetings and International Symposiums at a variety of locations both inside and outside RAF Waddington over the period Oct 2009–Mar 2013. The researcher had access to a wide variety of (published and unpublished) documents that give insight into the safety culture both at RAF Waddington and in the wider RAF before, during and after publication of the Haddon-Cave (2009) Report. These included:

- Error Management Diagnostic (EMD) – 828 questionnaires completed by Engineering and Logistics personnel.
- Safety Culture Assessment (2010) – cultural study based on the Health and Safety Executive's Climate Tool.
- Maintenance Error Management System (MEMS) End of Year Report (2010) – end of year summary of MEMS across 12 RAF Stations.
- Aviation Safety Management Plan
- No1 Group, No. 2 Group, RAF Kinloss, RAF Waddington draft Safety Manuals.
- Command Continuous Improvement Maturity assessment.

2.3 *Phase 2*

A further 21 interviews were carried out Mar-May 2016. By 2016safety management documentation had become clearer and more formalised:

- RAF Safety Management Plan (AP8000)
- No1 Group Functional Safety and Environmental Management Plan
- No 1 Group Air Safety Management Plan
- RAF Waddington Total Safety Management Plan

In addition to follow up interviews and document analysis the researcher took part as observer-participant in a three day, contractor-led Defence Aviation Error Management System (DAEMS) Post Technical Support visit to RAF Cranwell. A number of focus groups, master classes and interviews were held with over 100 personnel from across all ranks, as well as civilian support contractors.

2.4 *Data analysis*

Interviews were recorded and subsequently transcribed. The data was manually analysed to identify themes. A set of *a priori* codes were produced based on the interview schedule headings and sub headings. An iterative approach was taken to analysing and re-analysing the data set to further develop these codes as new themes and sub-themes emerged following the process outlined by Miles and Huberman (1994).

3 RESULTS

Participant responses were organized around the following broad categories:

– Nimrod Crash: Awareness/Views of the incident
– Nimrod Review: Awareness/Understanding of report recommendations
– Personal Impact: Of event/Of subsequent changes
– Organisational Impact: Risk/Likelihood of reoccurrence/Safety Campaigns/New Structure & New Roles/Fear of litigation
– Culture: Military/Learning/Questioning/Just/Reporting
– Barriers to change
– Facilitators of change

3.1 *After nimrod—awareness and impact*

All participants had some knowledge of the Nimrod crash and Inquiry to a greater or lesser extent and all could identify structural changes that had occurred. Most perceived that Nimrod had been the catalyst for change in a positive way although by the latter stages some thought that complacency was starting to creep in. In the immediate aftermath many thought that the organisation was vulnerable to another event. By 2016 most thought that the management of Airworthiness and Air Safety had "enough momentum now to endure".

There was some early evidence that people believed the organisation had become *risk averse*, partly in response to a perception of a greater chance of litigation. The narrative shifted over time and many people stated, "we are not a risk-averse organisation". Some however, felt that the pendulum had swung back and statements such as this could be used as 'cover' for not digging too deeply into safety concerns; and by implication allowing managers to 'push on': "I think initially safety comes first but then when the pressure comes…safety maybe isn't the full priority". Risk management (RM) is an area that appears misunderstood by much of the organisation and when mitigations and barriers are documented as reducing risks to an acceptable level, their efficacy is not routinely tested. Post Haddon-Cave RM is largely still narrowly focused on Air Safety (Risk to Life). Functional risks appear less well understood.

Prior to Haddon-Cave, Waddington had a very disparate approach to aviation safety where different types of safety were managed by different parts of the organization. Some upheaval and apparent discomfort was felt when existing roles and responsibilities were 'challenged' by the new procedures and processes after Haddon-Cave. Over time there has been an attempt to align the disparate areas under one Total Safety (TS) construct. Although this was seen to be a step in the right direction, it was perceived to be having a limited effect due to a lack of real integration of safety expertise and assurance activity. There is considerable overlap in some areas and apparent gaps in others. There was evidence of spending more time carrying out assurance-building schemas and processes than investigating issues. "I think we may have gone a little bit too far right of arc with regard to the amount of assurance that we are doing; to the point that we are doing so much assurance with limited manpower…that we are spending more time pushing paperwork than digging into the nitty gritty and actually finding out what could be going wrong". Additionally, safety management leadership was felt to be evolving 'bottom-up' not centrally driven.

Some that safety has become a 'cottage industry' 'sucking' life away from the frontline: "There is more governance; the big joke now is that you have more people assuring than turning spanners…" Audit fatigue and SMS processes were seen as a burden although most people agreed that the new assurance processes were necessary. Increased engineering oversight in particular was largely seen as a good thing. The reporting culture was perceived to be good and improving all the time although it was seen by some as a way to 'protect' individuals when something had gone wrong. Some saw this as a way of 'passing the buck' or getting top-cover for risky behaviours. The myriad of different reporting systems had caused confusion in the user community and led some to worry that significant safety issues might be falling through the cracks. Reporting systems matured to some extent over time and participants seemed happier that people knew how to report. Local workarounds were helping to overcome the wider systemic problem of a lack of integration. Despite some middle management disquiet about: "airing our dirty linen in public" the majority recognized the benefits of learning from other people's mistakes.

3.2 *Barriers and facilitators*

The British military are often described as having a 'can-do' mentality but some participants felt that 'getting the job done' often meant cutting corners, coming up with 'workarounds'; not following the written procedures. A reluctance to be seen as someone who does not 'get the job done', was seen to be due to an *organisational culture* of 'achieving' and 'problem solving', but also because of fear of detrimental impact on careers. There were examples of situations where individuals had decided to say, "stop" but these were perceived to be isolated incidents where things had got so bad that to continue would have been foolhardy. The normalization and transfer of risk-taking from war-fighting theatres back to peacetime operations in the UK was also seen as a potential barrier to safety. The majority felt that operational needs would always come before safety.

Perceived pressure from above was felt by many of the more junior managers but was in contradiction of the stated intent of the senior managers to put safety first. A widely held belief is that *resource-to-task* is inadequate. "I am worried that we are being asked to do more and more with less and less; something's got to give". Most people believed that there was "no fat left" and often they are 'double or triple hatted' i.e. doing several roles. There also appears to be 'gapped' posts in some key safety areas. Reservists are increasingly being used to overcome the disruption caused by *'churn'* and to give stability to key safety roles and to overcome the loss of corporate memory, which is exacerbated by *immature databases* and almost non-existent *data analysis / exploitation*. Manpower for safety and airworthiness was being resourced at the expense of, or putting pressure on front line activity. Some pointed out the difficulties of competing demands of EITHER getting the job done OR being safe. The major reason that people were perceived to be using workarounds was because they didn't believe that they had enough people to do the job properly. Most still saw *safety activity as a burden* that could get in the way of output but a 'necessary-evil'.

Lack of understanding and *resistance to change* were seen as significant barriers to cultural adjustment. Over time there seems to be less concern that individual *'blockers'* were trying to undermine the system however a recurring theme was that progress COULD be and HAD been hampered when a manager is posted in that does not whole heartedly commit to the new paradigm. Politics and career progression were often perceived to be management's main drivers rather than system performance. *Organizational inflexibility* and the *hierarchical structure* of the MOD were perceived to be holding back progress: "When you look at a safety culture; the whole idea of it being flexible, learning, reporting and just and all that stuff. Okay we may be getting there on some of that stuff but flexible organization? I don't think we are as the military; a learning organization? Well I don't think that either. I don't think we are flat enough to learn properly. So the things that we learn at the grassroots don't actually get to high-level, to a high enough level to get into policy. So as an organization we don't particularly learn well".

The main facilitator for change identified by the participants was *'Leadership'* both by the Station Commander and the MAA. Whilst no one questioned the Station Commander's commitment, few felt that the MAA as a relatively new organisation was entirely capable yet of providing the direction and guidance required. Many felt that Waddington was influencing Command Policy 'bottom-up' and few people understood what the RAF Safety Centre was for. Most were reasonably happy with local leadership however also some scepticism about the RAF's higher echelons being really committed to safety: "It is about safety leadership. You read the stuff in AP 8000, statement of commitment or whatever and it is strong & signed off at the right level. I am not sure it is actually understood at that level. You sign off what is presented before you but you don't necessarily understand what you are signing for; you agree with it but you don't necessarily understand it in depth".

There was a sense that despite difficulties, the organisation had a sufficiently *motivated workforce* that could quickly adapt to the new safety regime. Evidence to support this can be seen by the fact that over 1000 Aviation Error Management System (AEMS) reports were submitted across the RAF in the 12-month period after Haddon-Cave, compared to 10 reports submitted in 2008 under the previous reporting system, a hundred-fold increase. The reporting rates continued to grow throughout this study at a rate of about 10% increase year-on-year. As well as underpinning an improved learning and safety culture, personnel commented that *open reporting* overcame individual 'blockers' in the system as there was now: "No place to hide…"

Although a burden, many personnel felt that the mandatory *Safety and Human Factors Awareness training* would facilitate the implementation of the Haddon-Cave recommendations and fostering of a Safety Culture. Other factors identified as facilitating culture change include *System Confidence* and *Demonstrable Success.*

3.3 *Safety culture*

Participants were all aware of at least two of the structural changes that had come about as a result of Haddon-Cave (2009). The findings of the EMD contrast with the findings of Phase 1 of this research some 18 months later by which time 150+ AEMS forms had been submitted and 27 Occurrence Safety Investigations (OSIs) carried out at Waddington; representing a *willingness to report* individual as well as system errors.

A key concept now established is the notion of *SQEP* (Suitably Qualified and Experienced Personnel) for those personnel with important safety and risk management roles. This represents a significant challenge to the established way that personnel are managed throughout the organisation. Although the Station Commander is now legally accountable as the Duty Holder for the aviation risks on station they have little or no control over the personnel that work in key safety roles. Most SQEP were not formally selected for their safety expertise prior to coming into post and most had to qualify after starting the job. There appears to be no over-arching strategy for 'growing' SQEP. It was also noted that key safety people tend to be "the sick and the lame" i.e. those who cannot be deployed due to medical or other personal reasons. Many of the participants thought that individuals throughout the organisation were now more *questioning* of themselves and others; "Consciously I probably look at the things I do when I get into an aircraft…slightly more than I did before".

Despite assertions from senior management such as about commitment to a *Just Culture*, the quote below accurately paraphrases a common view voiced during the first part of this study. "I think there is still the culture of headhunting; when something goes wrong we still try to find someone to blame". Personnel appear sceptical until exposed to specific examples or until they are personally involved in an incident and subsequently find that blame is not, inappropriately attributed. Some thought that individuals would be able 'hide' behind the policy and therefore 'get away with' behaviour that should be punished. One high profile incident had set progress back significantly in Phase 2.

There was a general feeling that the RAF used to have a safety culture in place but that they had taken their 'eye off the ball' "I think the priority was shifted, the focus was on saving money" Some felt though that there were signs of improvement, particularly with the management and understanding of risk however, there was a sense that in other ways the organisation was still "carrying on as before" particularly on operations and that hierarchical structures and historical trade boundaries stand in the way of the organisation becoming a *flexible, learning* organisation. There has been no fundamental shift in the way that the organisation is structured and trying to meet the aims of Haddon-Cave without properly resourcing it had, some felt, built in more, unnecessary complexity. "In terms of trying to deliver in the short-term, maybe just modifying what you already got is the simplest and cheapest option, and also in terms of delivering change anything bigger may have been met with increased opposition. So it might be a case of trying to do what you can rather than what you need to do" There was evidence of *perceived pressure* from above however many thought that self-induced pressure was probably more of a concern. "We don't like to fail". It seems that Can-do persists for many and that short cuts and workarounds are still used to achieve output when the 'heat' is on.

4 DISCUSSION

4.1 *Structural and cultural adjustment*

Whilst there have been some structural changes at RAF Waddington, it is not immediately obvious whether they have gone far enough in order to foster a really open and engaged safety culture. There are a number of positive cultural indicators that suggest improvement, however there are also some fundamental challenges that may be holding back progress, and may even be making things worse. There is a weary acceptance by many of Waddington's staff that the structure of the organisation will forever be in a state of constant reorganisation to accommodate the lack of people, or to satisfy individual middle/senior management agendas. Major reorganisation (though not fundamental) has put strain on frontline capabilities because it was not resourced. This has been addressed to a lesser extent by employing reservists but this is a drop in the ocean compared to what may be required. The bureaucracy of safety management is clear to see and growing but whether this flurry of safety activity masks the true nature of Waddington's risks is not obvious to an outside observer or even to those involved. Most participants agreed that the organisation was safer in the wake of Haddon-Cave but few thought that they were as safe as they should be.

It is clear that the participants do not yet think that the organisation has found the right balance when it comes to RM. Emergent hazards and risks do not appear to be hunted down as RM is narrowly focused after Haddon-Cave. There has been an attempt to widen the field of focus but this creates two problems: For some straying away from Haddon-Cave's core principles dilutes efficacy. For others targeting too narrowly risks placing too much emphasis on one particular aspect of safety at the expense of the real issues that may be hurting the organisation. The *fear of reoccurrence* noted in Phase 1 hasn't been lost…although this does not necessarily mean that disaster is inevitable since a heightened sense of unease may help to overcome *complacency* as in high reliability/resilient organisations. It may now mean that the organisation is more *risk-aware*. The danger of course could be that this 'fear' only resides within enlightened individuals who may be *insufficiently empowered* to make a difference.

So has full cultural readjustment taken place as suggested by Turner's (1978) model? It is clear that some progress has been made but that the picture is a mixed one. This research may raise more questions than it answers about whether cultural readjustment is even possible, whether foresight can or will be generated, or whether disaster is inevitable in highly complex socio-technical organisations.

4.2 *Safety culture*

As Haddon-Cave (2009) points out "There is much to be learned from the work of NASA and the US Joint Planning and Development Office who have adopted Professor James Reason's four-part approach to creating an "Engaged" Safety Culture which includes four elements: *Reporting / Just / Flexible / Learning.* Haddon-Cave added a fifth culture to this list and this has been included in the RAF SMP (AP8000). He believed that a *Questioning Culture* was also fundamental. In the seven years since Haddon-Cave personnel at RAF

Waddington have shown an increasing willingness to report accidents, incidents and near misses. This is mirrored across the wider MOD.

Once given the training, processes and mechanisms to report, personnel began to highlight problems to management that had been unknown to them under the previous command-chain and accident reporting systems. However there are issues: too many reporting systems, some underpinned by mandatory legislative requirements. Confusion has resulted in some mandatory reportable incidents being reported on the wrong system, or not reported at all; insufficient occurrence investigators available to carry out investigations; reporting systems seen as too unwieldy and difficult to use; differing perceptions as to what some reporting systems are for; perception that some of the reporting systems are more 'visible' to senior management, fostering the notion of too much outside interference; the view of "airing dirty linen" has waned over the years but still encountered; a belief from some that personnel may 'abuse' the system and report to 'offload' difficult management issues; quality of reports varies significantly regarding their value for hazard identification; belief that 'others' report to protect themselves when carrying out risky behaviours to protect themselves from accountability; embryonic data analysis and "doing what we can" within resource constraints.

There is wide spread recognition that Waddington is striving to be 'just' and fair when things go wrong (Dekker, 2007) but it is not yet fully embedded. The sentiment that Just Culture is 'hard-won but easily lost' was voiced time and again. Where formal safety investigations are carried out the belief is widely held that people will be treated fairly and appropriately. Outside of these investigations doubt still remains. The complexity of RAF Waddington and wider MOD as an organisation, makes being flexible extremely difficult. Constraints on finance, infrastructure, recruitment and manning, policy and materiel all act to narrow the options available. Although some involved in Waddington's SMS have a vision of what their organisation could look like, this does not seem to be mirrored at a strategic level in the MOD. No one interviewed could articulate or point to a high level vision or strategy for growing safety management expertise or fostering a safety culture.

The basic organisational command structure and hierarchy still exists and the organisation still procures and operates in much the same way as it did before the Nimrod crash. The researcher had an opportunity to talk to Haddon-Cave after he gave a speech at the Royal Aeronautical Society in 2015 where he stated his belief that the MAA was on course to be a world class regulatory body. This view was not widely held by Waddington's personnel. The move towards even more contractor support seems unstoppable regardless of what impact this may have on the RAF's skills base and corporate knowledge.

At the present time there is limited expertise throughout the organisation at interrogating and analysing safety data and few people have the time to even begin to look proactively at the increasing volume of data. The taxonomies used to categorise this data vary considerably and reside in different databases; therefore gaining situational awareness of the current risk picture appears to be more about intuition than empirical evidence. Studies of organizational memory have shown the link to organizational learning so the lack of a joined up approach to the management and exploitation of safety data, and the churn of personnel may negatively affect corporate memory and therefore the ability to learn. Differing emphases of investigative approach e.g. identifying 'causal factor' versus 'root cause' can lead to single rather than double loop learning.

Military personnel and officers in particular are trained to 'deal with' issues however this approach may only treat the symptom rather than the cause and reduces the opportunity for isomorphic learning to take place. Organisational learning and error prevention can only come about when we 'drain the swamps' (Reason, 1990). Middle management in particular appear to be vulnerable to this mind-set. The elephant in the room for the RAF to become a learning organisation appears to be its *military culture* of can-do and a hierarchical structure where issues are dealt with lower down so the real risk picture is potentially 'filtered out' before reaching those that can influence policy. Policy appears to be changing and 'bubbling up' from the bottom. The question remains whether the organisation is hamstrung by its structure, culture and external factors such that it can only progress so far; can perhaps only be so safe. Despite some obvious examples of individual resistance to change there appears to be a willingness on the part of the population to prevent another disaster. Nimrod remains in the psyche of many of the interviewees although it seems that the event itself is less significant to the younger workers. The lack of awareness in this cohort may not represent a vulnerability as they seem willing to report and the safety management system processes appear to be more 'daily business' than in the earlier part of the study.

5 REFLECTIONS ON TURNER'S MODEL

It is clear from this research that cultural readjustment is a many-layered, recursive process of change. It involves a complex mix of Contemplation, Preparation and Action (Prochaska et al. 1992) at individual, team and organisational level. This is fraught with difficulty. Even when public inquiries are effective at identifying the causes of disaster, they still have to make appropriate recommendations that must be achievable and grounded in reality. Disasters are uncomfortable events to go through for any organization and so is the subsequent adjustment. This change needs to be managed to be effective. It can't just 'happen' by ticking off a list of recommendations post inquiry. When change does occur there will be many factors that work for and against and sometimes making structural changes are the easiest thing to do. These, along with the inevitable flurry of safety activity may give the illusion of safety through increased safety bureaucracy. Improved safety culture takes time to achieve and individuals and teams will go through the process of Contemplation, Preparation and Action at different times and at different paces. Individuals (whether as *heralds* or *blockers*) can have a profound influence on the efficacy of this process. When the dust settles the organisation may well find that a culture shift has occurred, however only time will tell whether the new norms and beliefs have made it safer. Even then there will be ongoing *disrupting factors* that mean that rather than an end-state of "cultural readjustment" organisations are more likely to settle into a new *quasi-stationary equilibrium* (Lewin 1947a). Turner's (1978) model does not easily account for the findings of this research. In fact no stage model can easily sum up the complexity or recursive nature of cultural readjustment therefore more work is required.

6 LIMITATIONS AND FUTURE WORK

Although this research took place over an extended period of time it was still limited in its sample size and scope therefore extrapolating to the wider organization or other industries may be difficult. Additionally the researcher was inevitably involved in the changes that took place in the wake of Haddon-Cave and therefore maybe too close to be entirely objective. Future work could involve revisiting the RAF to carry out a third phase and to carry out a similar case study in another safety critical industry e.g. Rail. The data from this study and future work will be used to develop a model that may better describe the process of cultural readjustment.

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Developments in analysis of severe adverse events in healthcare—policy and practice in Norway

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ABSTRACT: Analysis of the most severe events in healthcare often reveal that early warnings and weak signals were misunderstood, missed, or discounted by professionals, managers, and organizations with mandate to monitor quality and safety. This is also the case in Norway and some high profile severe adverse events have marked a call for developments in methods that incorporate principles from accident theory, qualitative methods, and user involvement in order to increase understanding of the complex causality. By ways of a qualitative thematic content analysis of national policy documents, we explore the developments in the analysis of the most severe events in the Norwegian healthcare system. The analysis focus on the political and public engagement to change analytical methods, and how methods of the investigation practice have developed the past 10 years in the light of disaster theory and qualitative research methods.

1 INTRODUCTION

1.1 *Background*

International healthcare scandals, such as the Midstaffordshire and the Bristol case in England (Francis, 2015; Kennedy, 2001), have shown that uncaring and ineffective practices have been going on for years due to no or insufficient reactions to warning signals (Braithwaite et al., 2015; Francis, 2013; Mannion & Davies, 2015). Despite of improvement efforts, healthcare is still infested with accusations of an individual blame culture, supported by professional cover ups of adverse events (Johnstone & Kanitsaki, 2006; Wiig & Lindøe, 2009; Woodier, 2015), and a fear of whistleblowing (Mannion & Davies 2015; Waring 2015). Healthcare professionals, managers, and regulators have been accused of avoiding open communication with patients and next of kin after adverse events resulting in a search for the truth of what actually happened and caused the adverse events (e.g. Aase & Rosness, 2015; Aftenposten, 2015; Francis, 2013; Hannawa et al., 2016; Helsetilsynet, 2015a,b; NOU 2015:11; Woodier, 2015).

Analysis of the most severe events in healthcare often reveal that early warnings and weak signals were misunderstood, missed, or discounted by professionals, managers, and organizations with mandate to monitor quality and safety (Macrae, 2014; Macrae & Vincent, 2014). This is also the case in Norway and some high profile severe adverse events (e.g Daniel case, Benjamin Case) have marked a call for developments in methods that incorporate principles from accident theory, qualitative methods, and user involvement in order to increase understanding of the complex causality (e.g NOU 2015:11, Aftenposten, 2015).

Learning and blame are two key issues in this debate. As pinpointed by Macrae & Vincent (2017:90), learning from the past to improve the future is the most fundamental principle of patient safety. In order to do so, there is a need to review the organizing and development of roles, sanctioning power, investigation methods and competence, to asses if healthcare is set up to fulfil learning as the fundamental purpose within such a highly complex socio-technical system.

1.2 *Aim*

The aim of this paper is to explore the developments in the analysis of the most severe events in the Norwegian healthcare system. We focus on 1) the political and public engagement to change analytical methods, and 2) how methods of the investigation practice have developed the past 10 years in the light of disaster theory and qualitative research methods.

2 METHODS

The paper is based on a qualitative thematic content analysis (Pope et al., 2006) of national policy documents such as reports to the parliament, white papers, public hearing documents, and selected high profile investigation reports from the Norwegian Board of Health Supervision (NBHS).

NBHS is the national regulatory body for the health and care services, responsible for investigation of the most severe adverse events. NBHS is an inspection body with sanctioning power against healthcare professionals and organizations. In a sample of the most severe adverse events, the NBHS conducts on-site visits to collect information for the regulatory follow-up. This type of inspection activity was implemented as a pilot in 2010 and established by law in 2012. An inspection report is published when the regulatory investigation is completed. Such reports are used as data in our study in addition to the NBHS own annual reports from the unit conducting the inspection activities related to the most severe adverse events.

The analysis of policy documents includes a Norwegian Official Report from a law commission (Arianson-commision) with a mandate to: "*Follow—up of serious adverse events and suspected legal violations in the health and care services*" including an assessment of pros and cons with an independent investigation board for the health and care services. Moreover, it includes analysis of a newly approved legal act with its preparatory documents on "the National investigation board for the health and care services" approved by the Cabinet June 6th 2017 (Act, 2017; Prop.68 L, 2016–2017). Finally, four reports to the Parliament on patient safety and quality (Meld. St:2012–2016) are included in the data material.

All the data collected as part of this study, are publicly available and downloaded from the Internet. No ethical approvals or informed consent were required for the study.

3 RESULTS

3.1 *Political and public engagement to change analytical methods*

The results show an increasing attention from the public (patient and next of kin organizations) and from policy makers to emphasize the patient and system perspective in accident investigation. The Parliament has decided to publish an annual patient safety and quality report and the Norwegian healthcare system has improved the oversight of types and scope of adverse events. Key topic in these reports are user involvement, a culture and system for openness, and the role of leadership in quality and safety improvement (Meld St 10 (2012–2013); Meld St. 11 (2014–2015); Meld St 12 (2015–2016), Meld St 13 (2016–2017).

The committee elaborating NOU 2015:11 (Arianson-committee) was divided in the conclusion related to the proposal of establishing a special independent investigation board for the health and care services. The majority fraction was opposing this proposal, claiming that the resources rather should be used for strengthening activities related to safety improvement and investigation activities on enterprise level.

The minority fraction claimed that establishing an independent board on national level was a community responsibility towards involved patients and their relatives. The work of such a board can according to the minority fraction come up with knowledge that other bodies (as e.g. police and supervisory institutions) are not in position to find, and thus stimulate learning and changing of practice better than seen today. An independent investigation board can approach a broader field than traditional investigation systems and also go deeper into the causal chains by using a wider set of methods than usually done by administrative and judicial bodies.

3.2 *Regulatory analysis of adverse event*

Investigation reports from the NBHS demonstrate a change in analytical approach from an individual perspective to a system perspective emphasizing the learning aspect from the events. The methodological approach in the data collection has developed from being mainly oriented around written information exchange to include methods also focusing on qualitative interviews with involved healthcare personnel and managers, in addition to include data collection from patients and next of kin to include the patient perspective in the investigation.

To specify, we will illustrate by insights to the Daniel case where a three-year old child died after a routine tonsillectomy in 2009 (Helsetilsynet, 2015a,b). The regulatory follow-up and the police investigation were initially closed in 2010, but new information from the news media caused the regulatory case to be reopened in 2014. The Daniel case was characterized by cover-up, failure of the initial regulatory and hospital follow-up. During the reopening of the case, the NBHS was heavily criticized for using too narrow investigation methods and a lack of required investigation competence (Aftenposten, 2015). Then the NBHS used new data collection methods, beyond the ordinary written information exchanges, to understand the causality based on a broader picture of information from multiple stakeholders. Meetings and interviews were used for this purpose.

We have invited several of those who provided input to meet us and elaborate their points of view, to ensure we have a correct understanding of their view (Helsetilsynet, 2015b:14).

Based on the additional information the NBHS (Helsetilsynet, 2015b) changed parts of their conclusion in the regulatory follow-up and developed safety recommendation for system-wide learning to prevent similar adverse tonsillectomy events. The investigation also identified several preconditions for the severe adverse event such as a negative psychosocial working environment, professional collaboration climate, hierarchies, technical equipment, misperception, and miscommunications. In addition, the management did not meet the legal requirements of managing adverse event and a sound follow-up of the next of kin.

The Benjamin-case concerns with a young man who had been under surgery for a knee-injury (NOU 2015:11). During the night after surgery he suffered great pain and was given several doses of an analgetic pharmaceutical (Ketorax). The following morning he was found dead in bed. The relatives claimed that the hospital had not observed the patient in a proper way. In the first instance the supervisory authority did not initiate further investigations, but after critical questions from the parents both the police and the supervisory authorities engaged in the case. It ended with critical remarks towards the hospital from the supervisory authorities and the police decided to give a fine to the hospital for not working in accordance with the legal requirement for sound professional practice. But even after the final decisions in this case, the parents claimed that several questions remained unanswered. Among them were questions in the intersection between different legislations (working environment and health service provision). Questions related to the individual actions of involved personnel also seemed to be difficult to approach by the ordinary administrative and judicial systems as they were not able to gain evidence in a way not leading to self-incrimination of involved personnel.

The public debate around such cases as described above has led to amended procedures in the NBHS for investigation of adverse events, putting more emphasis on the communication with the relatives of the involved patients through the investigation process. This is becoming evident when studying the procedures for investigations as well as when comparing investigation reports from last few years with reports from former periods.

3.3 *Independent investigation board*

Since 2010 there has been argued for developing an independent investigation board for the most severe events in the Norwegian healthcare system. A Norwegian Official Committee (NOU, 2015:11) nominated by the king in council, developed a proposal for a new independent investigation board for the health and care services, including a new legal act.

The new act relating to "*The National investigation board for the health and care services*" was approved by the parliament June 2nd 2017, despite that the public hearing showed major resistance to this proposal among healthcare organizations. Still, the Norwegian Minister of Health and Care services and the majority of the parliament members argued and voted in favor of establishing the independent investigation board as a prerequisite for in depth investigation with learning purposes only (Prop.68 L, 2016–2017).

One of the key arguments for establishing an independent investigation board is the need for a broad investigatory approach to understand the complex casual factors in healthcare disasters that goes beyond the current methods of regulatory follow-up focusing on deviation from regulation and sound professional practice. Moreover, the need for a system-wide perspective addressing multiple stakeholders' (regulators, hospital, general practitioner, nursing home, healthcare professionals) role in the adverse event such as the creation of the contextual condition under which healthcare professionals operate, is highlighted. Also, a no-blame investigation is identified as crucial in order to bring forward information from the involved parties (Prop.68 L, 2016–2017).

The role of multi-disciplinary teams and competence addressing risk management, organization and leadership, accident investigation methods, law, working environment in addition to professionals from different healthcare professions, are suggested as a prerequisite in operationalizing the independent investigation board (Prop.68 L, 2016–2017).

4 DISCUSSION AND CONCLUSION

The rationale and principles underlying the development in the analysis in Norway have strong links to Barry Turner's theory (Turner, 1976; Turner & Pidgeon, 1997; Turner, 1994) and shows how understanding of complex adverse events needs information from multiple sources (patients, next of kin, healthcare professionals, managers, and inspectorates) at different system level. Policy documents and investigation practice have developed in a direction focusing more on the role of culture, openness and in particular managers' role in controlling risks. This can be related to a need to prevent "sloppy management" as a cause of disaster like Turner conceptualized it in his work. Sloppy management may cause that information is misunderstood or not communicated, and therefore healthcare managers need to question themselves if they have a realistic view of their organization and allow staff to bring forward alternative views and interpretations of their operations (Turner, 1994).

The investigation methods and analysis in the Norwegian healthcare system have developed in order to take into account complex causality of accidents and the multiple contributing factors such as working environment, culture, team-work, technical equipment and procedures and if an how these constitute underlying preconditions for the incubation period of the events under investigation (Turner, 1976; Turner, 1994; Turner & Pidgeon, 1997). The need for investigation methods that are able to uncover precondition and contributing factor beyond the triggers, combined with a need for improved learning from adverse, have resulted in establishing an independent no-blame investigation board in the Norwegian health and care service. This development equals to what has happened in the English healthcare system, where a new national safety investigator for healthcare (Healthcare Safety Investigation Branch) was established in April 2017. Both countries have decided to implement a system-wide, multidisciplinary and learning focused investigation board, equal to what other safety critical industries such as aviation, have had for years (Macrae & Vincent, 2017). In both countries, the development has started based on persistent effort from next of kin with negative experiences with the healthcare system.

In addition, our study shows the need for developing skills in qualitative methods among investigators and a multidisciplinary investigation team. This can be interpreted as a stronger acknowledgement of the need for diverse methodological approaches, scientific perspectives, and skills to understand how and why accidents happen in complex socio-technical systems. Our results arguing in favor of a larger methods repertoire and perspectives in accident investigation, equals to Martin & Turner's (1986: p155) argument about how the contribution of grounded theory in organizational research can provide important components for the researcher's "kit of tools" for making sense of—and improving—organizational reality. By taking advantage of e.g. qualitative interviews, observation, and face-to-face data collection methods in addition to traditional written information exchange, investigators' "tool kit" is enlarged and most likely contributes to improved understating of how and why adverse events happen and can be prevented in healthcare.

But still it remains an important and partly unsolved question on how to become aware of those minor signals often preceding major calamities in the healthcare system. It is still not clear whether investigation boards or reporting systems are able to discover malfunctioning service systems in an early phase.

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From safety to cyber security: New organizational challenges in Industrial Control Systems (ICS)

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ABSTRACT: Cyber security is a growing challenge for all organizations. In the past two decades, organizations have developed a huge amount of infrastructures based on important Industrial Control Systems (ICS) for their businesses. A specific domain of these challenges comprises the industrial organizations that manage railway infrastructures, public utilities, nuclear plants, communication infrastructures and utilities.

The aim of the paper is developing a conceptual bridge between organizational research on safety and new research program on cyber security in industrial setting. Working on data provided by an ongoing project on cyber risk in ICS, the paper suggest a preliminary framework to face with relevant questions and reflections on how the organizational social construction of safety can be in some way a good proxy to understand the sociotechnical side of cyber risk in industrial sites.

1 INTRODUCTION

Cyber security is a growing challenge for all organizations. In the past two decades, companies have developed a huge amount of ICT infrastructures based on important information for their businesses, and many practices have been developed through these innovation processes. A specific domain of these innovation processes is represented by industries that manage railway infrastructures, public utilities, nuclear plants, communication infrastructures, and so on. These companies' businesses are not just managing private businesses, but they deal with public interests and strategic resources like power, water, transports and so on.

From the past, these businesses were intended as developed through local practices and knowledge and shared initially through the market at local or national level. Today, everything seems to be driven globally. On this new scenario, organizations must be aware that their industrial plants are even more connected through the internet based protocols. It means that potentially every industry is permanently under 'observation' from 'outside', and that their data and industrial processes must be guaranteed not only by technological physical artefacts and surveilled boundaries from potential "attackers". Their security depends also by the protections thoroughly the virtual world. Through Internet, industries have to devote their attention against information theft, dangerous tentative to destroy part or all of their infrastructure for many different, not ever competitive, reasons (Macaulay & Singer 2012).

Otherwise, many events, often malicious, impose new constraints on the organization if they want to survive. Security policies, protocols, detecting practices and incidents/alerts management, are just some organizational practices with which to manage knowledge about security in the organization and to counter external cyber-attacks.

Historically organizational studies and management studies has been able to explore in many direction the safety's issues and through them has been able to suggest many relevant aspects on how organizations become dangerous for people inside and outside the organizations.

On the basis of an interdisciplinary cooperative analysis conducted on data emerging from the MUMBA project (Multi-Faceted Metrics for ICS Business Risk Analysis) active at the Institute for Security at the Lancaster University, we would present some preliminary findings of a special relationship between practices of security and practices of safety in industrial environment.

2 RELATED WORK

Risk is one of the main growing fields in industrial management. In the recent past IT literature has started providing many works related to how protect brands, data, IT infrastructures, local sites, local technologies for productive sites and so on. Many events and critical incidents are emerged to show how relevant and dangerous could be any attack provided to industrial plants or public utilities around the world. It is well represented by different international databases and by many works (Bayuk *et al.* 2012; Knapp & Langill 2011; Radvanovsky & Brodsky 2013). These works suggest that almost all economic sectors (Fig. 1) are interested and, because is difficult to know exactly how many attacks are addressed to the companies, it clear that the industrial risk is a persistent and widely explored field present in the agenda of any country.

The industrial risk is strictly connected to the knowledge of what the company are producing and to the physical and technological environment present in a plant. Historically it was a myth that industrial processes were immune by attacks because the environment outside the plant were separated from technological instruments adopted to manage it. Furthermore, as point out by many reports, until fifteen years ago ICS were based on proprietary code and standards, ICS operated in a benign environment and protocols and protocol implementations were therefore simple and not hardened against attacks. In this scenario hackers were not interested in ICS. But what it is important for us is that the knowledge was relevant at local level, regarding specific workplaces and a small set of experts. Nobody else was interested.

This was a scenario developed also for managing knowledge on companies, about safety. Safety has been studied by scholar considering mainly management issues, but after it had become clear that it depends from organizational cultures and the way people do their job in the organizations (Taylor 2012). In other words, as pointed out by Taylor, safety needs to take in account that different levels in an organisation have different influences on the safety-culture. These levels need to be understand through their workplaces. Executive and senior management, middle managers, supervisors and workforce teams are differently involved in this process. All the employees are requested to

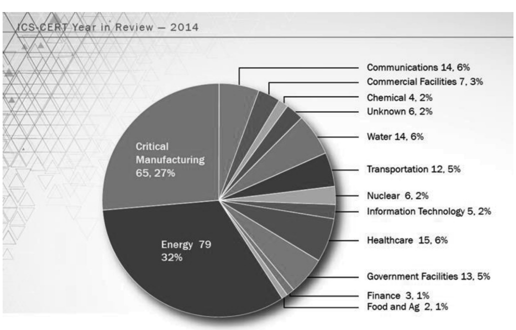

Figure 1. US ICS-CERT agency incident reporting 2014.

comprehend what safety means in a specific organizational environment. The researches have to consider these workplaces to move forward until the top management strategies, including discursive practices in different community of practices (Gherardi & Nicolini 2000).

In these works, "safety" still represented as something constructed along relationship present in the workplaces. Understanding what happen at a local level in every specific practice acted along the day work in the workplaces when people are in permanent interaction with other actors and technologies too, open a new way to look at safety in a sociotechnical environment (Bruni & Gherardi 2007; Luff *et al.* 2000; Latour 2005). In this way safety is best managed and understood if we put in light local practices and every performance that people arrange around them (Suchman 1995; Luff et al. 2000).

Risk is a relational topic as well. As shown by Boholm & Corvellec (2011), risk is something culturally constructed and his relevance is built through by organizational practice. They point out the theme that a risky situation at least requires a "risk object" a "relation" and an "object of risk". "The relationship encapsulates the proprieties the observer considers prominent, rather than reflecting the properties of the objects as such. One could therefore say that relationships of risk are expressions of cultural preferences" (Boholm & Corvellec 2011: 180). Risk is a cultural based issue and its relevance in an industrial site depends on the representation of its relevance, causal implications and strategic priority.

From these issues, we can assess some general assumptions that put safety and security in touch. Both are knowledge based organizational activities, driven locally and dependent on the sociotechnical environment and organizational culture available at workplace level. Many contributors studying safety have provided relevant theoretical assumptions. Among many we can refer to the work of Turner (1997), Rasmussen (1983), Reason (2000) and Leveson (2004). Combining their work and Schein's theory on organizational culture (2010) helps moving to more recent related work on what culture does in organizations.

Complex organizations like those that manage power grids, water systems, or nuclear plants have to consider this multiplicity. We can assume that there are many practices addressed to future risks following different orders and organizational strategic constraints. However, adopting the organizational studies approach, we can assume that risk and safety are both collective, situated and constructed by enacting practices around it (Gherardi 2009). Through these practices we have "to understand how unintentional and intentional actions can result in systemic faults and failures that could impact safe and reliable operation in today modern industrial processes" (Macaulay & Singer, 2012: 16). Again, these authors point out that through practices we often find opportunities for failure modes and processes on a day-to-day basis that go largely unnoticed. Giving attention to these event helps when something anomalous occurs. The analysis of the relation between risk and safety have to start from everyday practices and from the knowledge they represent. This work aims at exploring the challenges that this "new" field represents for organizational studies.

3 FIELDWORK

Analysis data is provided by a qualitative case studies research design intended to build a set of metrics. It is developed in collaboration with the cyber security management in the industrial sites of two big national UK companies. These companies are active in different domains and their activity is relevant to national infrastructures and to many public utilities. Furthermore these companies are important players for large public clients in many countries over the world and in many sectors. They offer tailored solution to tackle with cybercrime and cyber-attacks in the industrial sector. They also develop many other products as well. For example they develop specific technologies for communications and imaging analysis through CCTV protected environments. They have important competences in safety and in risk management, and are well known for this at the national and international levels.

During a period of eight months, meetings and dialogues at different level were organised with these companies, in different contexts. Progressively they have started to share their experiences with different customers and in different case studies. We have made ethnographic observations of these meetings and many interviews with managers involved in industrial security. In addition, we have carried a few interviews that were theoretically sampled, with an engineer in the water sector, a couple of hackers expert in ICS, and a couple of consultants on security in industry plants. Finally, two days at a national conference in ICS were included in the observation sessions. Settling some public rhetorical assumptions on risks in industry was an important first step.

Data analysis of transcribed interviews and fieldwork notes were carried following an ethnographic, reflexive, grounded-theory approach focused on connecting concepts, emerging issues, labelling and commenting. According to this, data analysis has been developed assuming the framework of the social construction of qualitative research. Its openness fosters the researcher's responsibility on theoretical work (Holstein & Gubrium 2013).

4 FINDINGS AND DISCUSSION

A core issue, when seeking data on industrial security, is dealing with the scarcity of open doors for researchers to collect data from companies. Many contacts had to be woven for a long time between researchers and management to obtain cooperation. In fact, security, instead of safety, is an open issue, something strictly related to the companies' brand.

When researchers visit companies to explore ICS risk issues, many frameworks emerge from the field. Some frameworks come up through the manager's vision, although they are not easily involved in this topic. When working on safety there are protocols, guidelines, internal manuals, norms and so on that are a clear starting point to evaluate what companies are doing. Comparing companies' prescriptions and norms is a well-defined task.

Table 1. Organizational knowledge spread by different roles.

N	Role	ICS sector	Organisation
10	Engineers in IT	Development of software for ICS: detecting, penetration test, mitigation, networks	Various companies
3	Engineer	Maintenance	Utility companies
3	Security manager	Security policy and team in organizations	Utility companies
3	Vendor	Appliances for ICS	Industry
2	Security expert (ex-hacker)	Hidden market malware, post-event analysis, fixing	CEOs of their own companies
1	Technical Engineer	Network reliability, penetration test in industry	CEO of own company
1	Engineer	PLCs testing	Power company
1	Scholar	Risk & safety analysis	University
1	Scholar	ICS analysis	University

Risk analysis, unfortunately, brings little guaranteed result. Even after developing the best security conditions, as prescribed by norms, one can still be missing many (potential) holes that technologies and protocols cannot cover at all. For these reasons companies are not happy to open their doors to researchers at any level, in particular at production sites. This is also the probable reason why organizational studies are not exploring this specific issue much.

However, organizations have several social constructed frameworks useful to explore risk management. For this preliminary paper we concentrate our attention on three main levels: management, local security engineers and security consultants.

4.1 *Manager's knowledge and official representations*

Managers' frameworks on risk is probably the more interesting element when observing the social construction of risk. Managers know what the risks are for their companies and they are aware of many the implications of this topic. Several surveys show that managers know how critical an industrial sector is under threats. At the same time a strong commitment on what should be done to deal with risk is not always part of their agenda. For instance, many companies have just one person dedicated to this activity as a security manager (Piggin 2015). Often, this task is provided by IT managers that have a point of view not comparable to the one of industrial engineers. As pointed out in an interview with a consultant:

> "Often the security governance in not an issue for the management. They are worried to consider too much their consultants or their managers because of the 'probability of risk' in their industrial sites. As usual you have got many alerts from a sites in the field but usually they are rarely due to cyber-attacks. So this event can be used against strong investments on security. Fortunately because of the brand economy view, many managements are changing their strategic position on this." [C2: Foods].

The managers of the companies we have met agree with this situation and confirm that internal report on security rarely have great diffusion at the board. One reason are the costs of the investments, and another reason is the internal organization. Adopting a new competence or a new risk manager stresses the stability of the organization. Also, in industrial control systems, risk is intended as a convergence between automation issues (PLCs, SCADAs, etc.) and IT architecture (protocols, access and identity, local resilience…).

Organizations have not much time to deal with these issues, and yet they still tend to miss concrete representations of the damages that cyber-attacks can cause their businesses. A possible explanation is the differentiation of points of views at different organizational roles.

Another concern regards international standards and certifications. Companies' governance must deal with these, especially when they deal with public customers or become a global player. However, not all standards are the same. Some of them address governance, others deal with technical structures. Nonetheless, standards are an institutional and international discourse on security that companies use to certify their security performances.

> "Some standards are addressed at a very high level, and this is important because if you want to write a norm for all players the standard have to be "high". Of course, it keeps you far from specific details. Further, there are technical standards that are absolutely different from each other. They are really specific and usually they are addressed directly to the engineers not to the management. Managers are used to work on the compliance with the international standards as the 27001 that require specific responsible roles in the companies. But, locally, there are many 'tailored" solutions that can reduce the effective technical impact of the standards" [C2: Public utilities IT manager].

Despite the low evidence of attacks in medium sized industries, managements—mainly the ones driving public utilities—have to deal with security at a growing rate. The past has shown only a few well-known events in big industries. However, the perception that all companies should be dealing with security issues and should intervene on the organizational knowledge management of risk has become concrete.

4.2 *Local security engineers: Exploring the workplace level*

While working with people involved at different organizational levels, we observed that many workplace practices are not represented as "dangerous" unless organizations change their representations of industrial cyber risks. In addition, knowledge available in organizations about ICS cyber risk is not available through all roles and operators. In local sites, division of labour is relevant to understand that knowledge on safety and security is not managed in the same way. Security is mainly a novel IT-related issue. Instead, safety is an almost acquired public knowledge, fixed by many rules and managed by automation engineers and safety devices. Usually, about cyber security, it is very difficult to share perception and discourses between different workplaces. Control centres on security are built remotely since they manage data coming out from many different sites and from many devices (e.g. SCADA). Safety issues are, instead, managed locally according to numerous documents and protocols already provided by standards and safety policies, procedures and devices.

> "These people here, at the remote centre, only see a restricted view. They have very little power over the operational process going on. So, if an alarm comes in, there is not much that they can do about it other than ring somebody to sort it out. There might be some limited functionality: if a very basic alarm came in from a device, they might reset that device remotely but it wouldn't go beyond that. [Instead] the people here at the local level have a very very detailed view of what is going on at the operational site. They know it at an engineering level [...]. [At the remote centre], if a high level of this alarm comes in, they only know that it is important, either [from experience] or because it is a number "5" on a criticality scale. Other than that, they do not have an engineering view of what is going on." [T1: Power engineer].

As reported by other works, a better convergence between safety and security still constitutes an opportunity for many companies. Many issues emerge from the separation of these two points of view that in big companies become two concrete and thoroughly different structures. Lack in communication between the two could offer more useful informed practices on security (Piggin 2013). Research data shows that sociotechnical environment dedicated to safety and specific practices learned around it are different and remain separated from security practices (Gherardi 2009). What is clear from our data is that people should be informed and trained continuously about how these two hierarchically separated worlds have in fact many links that oblige them to work in parallel.

A typical situation is when automation devices are stressed by maintenance crew for safety reasons. Engineers think about this situation locally. They know the physical constraints in depth, they have experience with the most common critical events, how to safely restore the system and put it again in production. However, in their minds, as we will show later, there is a clear hierarchy in their professional cultural assumptions: saving money and maintaining the production effective stand above all goals.

Managers are evaluated mainly on the production of their sites. Managers' bonuses depend on production performance: they are rarely connected to safety or worse, security. At local level, engineers are not interested in communicating too much to their hierarchy about critical alerts registered on the field. Production has to be maintained: if alarms come in and they are able to "solve the problem", for example resetting a PLC, not much care is paid to other things as long as the system works. Concerns arise only after an event happens so often that it could be related to a cyber-attack. Production comes before anything else. Again, if an alarm comes in and it is known to be actually dangerous, safety procedures are applied as prescribed by protocols and all the personnel have to follow them.

> "If a severe alarms comes in, there are specific procedures even for people like cleaners, receptionists and those people in roles completely separate. If the alarm was that severe on that site, there would be an alert, some kind of notifications for everybody on that site. Then all have to follow the procedure… Just like a fire alarm, if you think about a fire alarm you have to stand up in front of the building or things like that. […] It would be assumed in the first instance there is either a problem with the instrumentation itself that is monitoring that signal, or with the device responsible for generating the alarm, the RTU, the siren itself, the configuration of the SCADA workstations, the PLC, etc. It would be blamed on everything but an external threat actor. I think if it was something severe and you went and reboot something and the alarm went away and it fixes the problem, it depends from management to management, different types of facilities, but some managers would be very keen on exploring that further" [T2: Power engineer].

According to the experience of this engineer, knowledge about alarm situations is continuously lost. On the one hand, very few specific traces of these events are collected, and on the other hand, if an important alarm happens the official protocols must be followed. Although many maintenance activities are recorded in great details, their readability as security issues is quite limited. Engineers' tales are about getting things working safely, rarely securely. In fact, alarms at local sites are managed mostly as technical failures. It is only after multiple occurrences and multiple device replacements that an alarm could be interpreted as a security issue.

It must be also considered that people at lower levels are probably at the lower paid income of the company and their culture is neither strategic nor oriented to understand their workplace as a part of a big design. This consideration highlights the importance of organisational granularity at the local level.

Managers tends to reduce the impact of security policies because of their cost. Also, security managers tend to emphasize alert analysis because those critical and well documented are few.

4.3 *Security consultants*

Going through field data, a way to approach security practices and discursive practices as well is to understand the different orders that companies manage along their activities. In this perspective, security is an "imagined" order opposed to a disorder created by attackers. Both security teams and hackers could be represented in potential opposite scenarios happening in an organization. In fact, a starting point of hackers is to cohabit with workers in the workplaces in a hidden fashion. Many attacks start with a research by the attackers team on people's habits, on their passions, their feelings, their competency, family, networks, relationships and so on. Attackers overlap with operators: they are not interested in taking an exclusive control of a system.

> "Hackers are interested in controlling machines in a shared way. Their only focus is to hide any action on the machine when they act at a local level. They program their actions in a way that they can be taken when nobody is controlling the target. Consider that these control machines are always on and active because they are so complex that it is impossible to switch them off without any dangerous effect. If they turn them off, they pray, because nobody really knows what could happen when they will be restarted [H1: Security CEO].

Working on field sites requires learning the local operator knowledge, both at the physical and practical level, and this learning process is usually hidden and covered by normal operator practices. The machines have a great stability, they must always be active and any strange behaviour is a threat to the hackers' strategy.

> "They have many procedures to stop and analyse any anomaly that are quite strong. If they launch these procedures they will be able to detect you. If they detect you, usually they would be well prepared and able to block you quickly. In these moments it is important to stop every action to avoid any alert. To avoid these risks, you schedule these activities when you are sure that nobody can see you directly. Moments that are less crowded. When the attacks take place it is after many many days and months. It is also typical of classical attacks devoted to data extortion. When an attack is aiming at extracting data from an industrial site, they stay on it for a long time. In a case I had worked on, we discovered that the attacker were able to extract data for almost one year and an half" [H1: Security CEO].

Learning from the field is also a goal for hacker teams. They need to understand which activities are connected with a specific machine, when operators come in and work on it, in which way and so on. Such activities happen every busy day, with a lot of production staff to manage, maintenance, upgrade of systems, tuning to get the machines active for the production.

> "Many times, I had the feeling that in a design phase, when a designer starts to think about a possible attack or possible intrusions, for instance a worm, and investigate possible scenarios, often people say "Yes, well, it could be, but it is too much paranoid of an approach", or, sometimes people around say "It works, why are you guessing again on it, it works!" It comes more often from an automation engineer. In my experience, there aren't specific experts of cyber security working exclusively on industrial systems. They are represented just as systems designed by someone to produce something. And then come the operator and the IT manager. That's all." [C1: Security manager].

Considering the knowledge that must be managed in the workplace to fix such complex machines in a production line, the problem is that sufficient useful knowledge is not always available. Many machines are legacy, other might be very complex, others have been recently substituted and so on. So, if an IT/security manager comes to suggest a penetration test, that would not be welcome.

> "Note that in many industrial systems offensive experiments are forbidden. And many offensive security practices, such as simple port scanning, in an industrial context, could be potentially dangerous. A PLC could go down under a simple procedure like a port scan. The reason could be, on one hand, because the system is a legacy system, and on the other hand, because the machine's interactions are not completely understood. Sometimes operators do not know their system at all. […] So, you are often embarrassed. You don't know how the industrial system works exactly, how it could react under your tests, you are not allowed to make penetrations test, nor to apply specific procedures that were not documented in the site… What can you do? Often an error in these tests could cause trouble to the production, or worst it could hurt people as well. It is too dangerous, so you can't do any test" [C2: Security manager].

Knowledge in industrial systems is something distributed in workplaces and following different practical competencies. The fieldwork shows that many knowledge holes persist that people cannot explore deeply, but that hackers are searching into. Hence, when a hacker finds a vulnerability they have a bit of knowledge that probably nobody has in the industrial site. Again, their knowledge starts putting together security issues (how can I use a hole in the system?) and safety issues (how can I damage the system through this hole?).

In the fieldwork we point out the theme of knowledge repeatedly. From an organizational point of view, attacks to industrial systems are a knowledge and relational fight. From the inside, it is quite clear that knowledge is something connected with places and time, answering the internal organizational question: "where and when something should happen"? Many studies have pointed out that the analysis unit should be the local practices. This organizational 'brick' can be defined through the practical knowledge available in organizations, historically represented within closed boundaries (Suchman 1995). What is important to recall here is the sociotechnical dimension of reality: design is a matter of socio-materiality strictly depending on knowledge and its distribution around organizations (Bjorg and Carsten 2014). A practice is a hybrid, a basic unit, that shows us that when we act it happens not "under the full control of consciousness; action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled" (Latour 2005: 44). Following this path we can assume that one of the most important practices undertaken by organizational actors is narrating accounts of everyday work life. These tales show the core of the job connected to that practice; the process of the practice as social action, and eventually practices allow people to enhance the social construction of the reality. These accounts on workplace practices reveal what "doing do" in organizational life (Bruni Gherardi 2007; Czarniawska).

One can argue that organizations are the field where discursive practices may give an account of what people experiment in the workplace, and a strategic way to produce new insights on it.

5 CONCLUSION

A simple model could be adopt to represent an organizational scenario to give a linear view of different layers where risk management matters. But, considering tales and workplaces, we need to represent how knowledge is distributed in the relational texture of organizations starting from the division of labour at workplace (Gherardi 2006; Carugati & Rossignoli 2011).

As suggested by Hilgartner "risk is not something that gets attached to technology after the engineers go home, when the press and public arrive. Risks are constructed constantly as technological networks evolve. Social scientists must abandon their post hoc approach to risk, and move analysis upstream to the arenas where specialized professionals are working most intensively to extend sociotechnical networks" (1992: 52).

Again, this requires understanding that knowing is a situated activity and that knowing-in-practice is always a practical accomplishment. In organizations knowing is something that people do together in a workplace context. It is done in every mundane activity, when people work "together". "It describes a web of relationships among people, material artefacts and activities and regard the question on how to connect them successfully with the field" (Gherardi, 2009: 118).

In the field, the professionals that we have identified as the main net of the knowledge-in-practice texture, working on the accounts about the local knowledge are: managers, engineers, IT security managers, hackers and vendors. These roles represent different knowledge domains relevant to understanding, at the workplace level, what is relevant in term of risk for them (Green et al. 2014).

On one hand, knowledge domains represented by managers, safety engineers, vendors are represented as fixed, durable, rational. Instead, on the other hand, the knowledge of hackers and security personnel are represented as vague and strategy dependent. In fact, these domains feature a lack of norms, protocols and shared knowledge on how security matter on company sites. This recalls the organizational concepts on boundaries developed by Lucy Suchman through which she showed that boundaries are a social matter (1995). Every working group survives on a relation between owned social location and view of others social groups. These relationships sustain boundaries among organizational actors, "including boundaries between professional designers of technology and technology users. The distance of professional designers from the sites and activities that are the subjects/objects of their work has given rise to a range of techniques aimed at representing relevant others in ways responsive to design concerns" (1995: 59).

Following this path, accounts are oriented to construct and maintain such boundaries and preserve organizations from ungovernable confusion. At the same time, these accounts push organizations to apply standards and bureaucratic norms that institutionalize boundaries and practices useful to build an order in the organization. But, again, standard and norms are a waiver of any possible constructive communication.

The main visible cleavage about risk accounts is between production and safety managements. Safety management is oriented towards protocols and procedures and towards the quality of life in the workplaces. On the other hand, production wants things to work. Looking to our field, we can add that a new domain is driven by knowledge of security managers. They, more or less remotely, have to provide instructions and knowledge about risk in production sites. The matter here is that they are quite "new" in the industrial environment and they haven't the legitimacy to act in a production site that belongs to another domain since the boundaries of their domain are still under construction (Lave & Wenger 1991; Wenger-Trayner *et al.* 2014).

The security teams have many warnings to forward to business management that require money to fix up, and often they have to manage a knowledge that could potentially hurt production. The problem here is that they are not allowed to assess their knowledge domain because of the need to analyse the production and safety domain. But managers from production and from safety are scared by everything that could block the productions or damage any machineries. As collected accounts show, production requires specific and local settings that any experiment in security could disrupt. Just a port scanning in a PLC could be a dangerous activity, especially if the PLC is in a delicate production segment.

In this way we have to consider the security managers as a third pole of knowledge that must be investigated.

The more visible answer of security managers is to pass through bureaucratic practices. They suggest to monitor specific aspects such as access procedures, firmware updates, external devices protocols and so on, by tracing every step provided by users. But, again, in a productive process this is not enough. Practices there are more complex and still need day-by-day learning and adjustments.

Eventually in some accounts it emerges that organizations are growing in visibility and their brands could be increasingly affected by security issues. People inside and outside the organizations are starting to deal day-by-day security issues in a global perception. When something has happened in a foreign country, it is broadcast in the media as a risk that could touch everyone directly. This is, again, socially constructed, and help to open the mind of business managers and employees about sometimes that can affect their industrial life.

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Epidemiologic and temporal trends of work-related injuries in expatriate workers in a high-income rapidly developing country: Evidence for preventive programs

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ABSTRACT: This study aims to describe the epidemiology of moderate to severe work-related injuries [WRIs] in Qatar, a rapidly developing high-income country.

Consecutive data for all adult victims of moderate to severe WRIs was obtained, from January 1, 2008, through December 31, 2016, from the trauma registry of the national trauma referral center of Qatar.

A majority of the 5,773 WRI were males from South Asia. The leading mechanisms of injury were falls from height, road traffic injuries and falling objects. There was a 37% reduction of the incidence of injury per 100,000 workers, from 2008–16. The proportion of falls from height decreased during the study period and that from RTIs increased.

The improvements in worker safety in Qatar are reflected in their changing epidemiology and incidence. A nationally linked WRI database will provide data to guide the prioritization and formulation of future programs to improve worker safety in Qatar.

1 INTRODUCTION

Qatar is a rapidly developing high-income country in the Middle East. It has very diverse expatriate worker population that is increasing as the road infrastructure and FIFA World Cup projects ramp up for 2022 [1]. The great majority of the workers originate from South Asia [India, Nepal, Pakistan, Bangladesh and Sri Lanka] with the Philippines and Egypt as the other leading sources of expatriate labor [2].

While there have been claims of numerous deaths and injuries from WRIs in Qatar from worker advocacies and the common press [3,4]. The outcomes and costs of work-related injuries [WRIs] from falls from height and falling objects have been reported in an academic and empiric manner [5,6]. Likewise, other workers have described the epidemiology of WRIs, classifying the workers injured by nationality and highlighting the disproportionate risk of expatriate workers being injured as pedestrians [2,7].

This is a brief report to describe the epidemiology of moderate to severe work-related injuries [WRIs] that are treated and admitted to the national trauma referral hospital, the Hamad Trauma Center [HTC] from 2008–2016.

This project is a component of the 'Unified Registry for Workplace Injury Prevention in Qatar [WURQ]' Grant [NPRP 7-1120-3-288] awarded as part of the National Priorities Research Program of the Qatar Foundation. Its primary objective is to create a linked database to accurately measure and monitor work-related injuries in Qatar.

2 METHODS

The primary sample for this study was collected from consecutive data, for all adult [at least18 years] victims of moderate to severe WRIs, obtained from January 1, 2008, through December 31, 2016, from the trauma registry of the Hamad Trauma Center [HTC], the national Level 1 trauma referral center of Qatar. The HTC is the only Level I trauma center serving the entire country, receiving more than 98% of the county's trauma patients. The trauma registry at the study institution is compliant with both the National Trauma Data Bank [NTDB] and Trauma Quality Improvement Program [TQIP] of the American College of Surgeons-Committee on Trauma and collects data on all trauma activations with mechanisms of injury consistent with trauma, all trauma activations with International Classification of Diseases, Ninth Revision (ICD-9) codes between 800 and 959.9, and all trauma patients without trauma activation who are admitted to the trauma service and have an ICD-9 code between 800 and 959.9.

Moderate to severe WRIs were defined as injuries suffered during working hours or while traveling to or from work and severe enough to need admission to the hospital; work-related drowning, poisoning or heat related illnesses were excluded. Temporal trends in the demographics, mechanisms of injury and incidence rates were analyzed.

Variables collected and analyzed included patient demographics, type and mechanism of injury and road user type. Labour Force data from the Ministry of Development Planning and Statistics was used to compute for population-based WRI incidence rates [per 100,00 population].

Severely injured patients who died at the scene before arriving to the hospital and those with mild injuries who were seen, treated and discharged from the Hamad Medical Corporation (HMC) Emergency Department or at Primary Health Care Centers (PHCCs) were excluded from the study.

Descriptive analyses were reported as frequencies and percentages for categorical variables. Continuous variables' central tendency was described using means with standard deviations for variables with normal distribution (as assessed by the Shapiro-Wilk test), and medians with interquartile ranges (IQR) for variables with non-normal distribution. Categorical variables were compared using chi-square test or Z-test of proportions as appropriate. P value < 0.05 (two sided) was considered statistically significant. All statistical analyses were conducted utilizing the SPSS 21.0 Statistical Package.

Ethical approval for this study was obtained from Research Ethics Committee, Medical Research Center, Hamad Medical Corporation, Doha, Qatar [NPRP No. 7-1120-3-288].

3 RESULTS

There were 5,773 patients, suffering from moderate to severe WRIs during the study period, who met inclusion criteria. Their key characteristics of are summarized in Figure 1. Most of the workers were males (93.4%) with a mean age of 29.3 years. An overwhelming majority of the workers (98%) were expatriates; workers from South Asia [Nepal, India, Bangladesh, Pakistan, Sri Lanka and Afghanistan] comprised a majority of the victims. The leading mechanisms of injury were falls from height, road traffic injuries [RTIs] and falling objects [FO]. Overall mortality was 12.9%, the most common mechanism of fatal injury was falls (49.5%) [Fig. 1].

There was a gradual reduction of the rate of severe WRI, per 100,000 workers, with a peak in 2011. Moderate and severe WRI rates dropped by 37%, from 53.9 to 34.0 per 100,000 registered workers during the study period, despite a 77% increase in the worker population [Fig. 2].

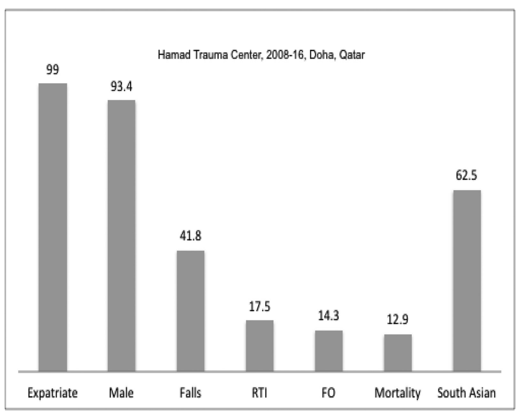

Figure 1. Key characteristics of severe WRIs [%].

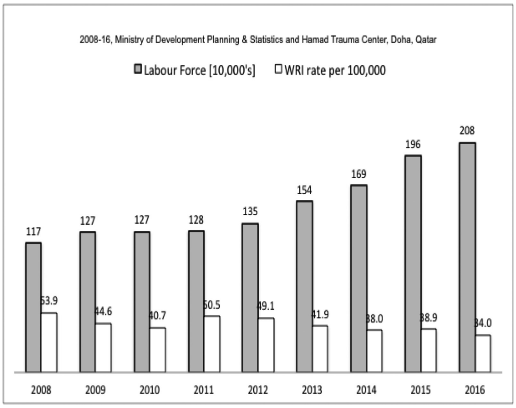

Figure 2. Annual labour force [100,000's] & WRI rate [per 100,000].

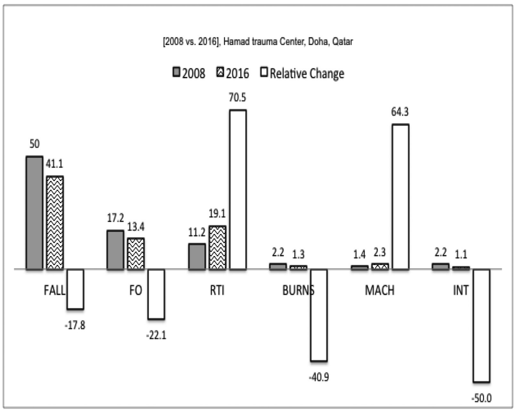

Figure 3. Proportion of WRIs, by mechanism & relative change.

The proportion of severe WRIs caused by Fall and FO decreased during the study period and that from RTIs increased. The greatest relative increases, during the study period, are noted for RTI +70.5% and Machinery Injuries [MACH] +64.3%. The greatest relative reductions were noted for BURN −59.0% and Intentional Injuries [INT] −50.0% [Fig. 3].

The most common nationalities of patients suffering from WRIs are shown in Figure 4. Overall, during the study period, the leading origin countries were: Nepal [23.3%], India [18.7%] and Bangladesh [11.0%], 44.4% of all WRI patients were from South Asia. Expatriate workers were disproportionately represented in the WRI population when compared to the general labour force, 99% vs. 94% [$p < 0.0001$] [8]. Of note, the proportion of WRIs in Bangladeshi workers increased relatively by 196.4% during the study period with Ethiopians

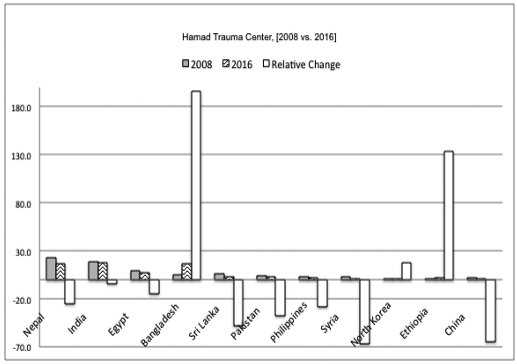

Figure 4. Proportion of WRIs, by nationality & relative change.

increasing by 155.5%. All other South Asian workers had relative reductions in their proportion of WRI patients; in decreasing order: Sri Lanka, Pakistan, Nepal and India. WRI patients from Arabic-speaking countries made up 13.8% of the study population [Figure 4].

4 DISCUSSION

Contrary to reports from various media outlets, WRI rates in Qatar have been decreasing despite dramatic increases in the worker population in the highest risk industry, construction. The origin of the majority of the WRIs is South Asia but the demographics are changing, with a notable increase in the number of workers from Bangladesh. Falls from height are still the leading cause of WRIs but RTIs have been increasing during the study period.

This report analyzes a nationally representative sample, representing moderate to severe WRIs admitted and treated at the national trauma referral center, and reports trends from a significantly long study period of 9 years. Many of the trends reported are reflective of the significant changes that occurred in Qatar during the study period: from the near doubling of the worker population [8], expansion and implementation of more stringent laws [1] for worker safety to the development of a national trauma system [10], with a Joint Commission International [JCI]-accredited ambulance service anchored by an Accreditation Canada International [ACI]-accredited trauma center. [11] The 37% reduction in WRI incidence rates, in the face of continued construction at multiple locations, cannot be attributed to a single factor and is most likely a product of the collaboration of several stakeholders in the field of worker safety in Qatar.

The application of retrospective sampling using a registry that was not purposely designed to collect data on WRIs allows for the limitations one should expect, primarily incomplete data with insufficient details. Similarly, data on mild and moderate WRIs as well as on work-related poisoning, drowning and heat-related illnesses were not captured in this analysis. Lastly, data that describes the worker populations by nationality and industry is needed to better design targeted safety programs that will be culturally, linguistically, industry and mechanism specific. However, this initial analysis is evidence that the creation of a multi-sectoral, linked database that is purposely designed to collect more detailed data on WRIs is needed to overcome some of these identified limitations.

The persistence of falls as the leading mechanism of WRI throughout the study period has been reported previously [5,9] and this report serves as a reminder and update that the use of safety equipment, like harnesses and worksite barriers, and consistent worksite inspections to prevent construction site falls should still be the priority for worksite safety in Qatar.

Road traffic injuries, disproportionately affecting young men, are the leading cause of death in Qatar [12] but this is the first report to identify prevention of RTIs as another leading priority for worker safety. A significant proportion of pedestrians in work-related RTIs highlights the need of a culturally appropriate prevention intervention [7]. That 78.3% of all work-related RTIs were MVCs is a call to differentiate the victims as either passengers or drivers and by vehicle types because these characteristics will inform targeted worker road safety interventions.

While the majority of victims originated from South Asia, the temporal changes in the proportional WRIs by nationality of the victims has implications for occupational safety education programs and interventions. More efforts must be made to implement language and culture appropriate intervention for worker safety and partnering with expatriate community leaders and organizations. These findings agree with previous work on the language capabilities of workers in Qatar [12]. There must be a focus on the growing Bangladeshi worker population and possibly replace Arabic and English as the languages to be used in educational materials, safety signs and training courses.

This initial report has identified clear temporal trends and priority populations, industries and mechanisms of work-related injury in Qatar. It has also identified areas for more detailed investigation and exploration of risk factors and circumstances preceding these injuries. The continued work of the grant, that this study is a component of, will contribute to the pool of evidence and data that will inform future efforts to keep workers safe in Qatar.

5 CONCLUSION

Hospital admissions rates due to severe work related injuries have been declining in the past 9 years. There are also clear-cut trends for the nationality and mechanism of injury of WRIs in Qatar. However, these numbers are representative of patients admitted to the national trauma center only, and do not account for less severe injuries and those who are seen and treated elsewhere. Further studies are needed to determine the true burden of work-related injuries in Qatar, with a focus on defining strategies for occupational safety and injury prevention.

The improvements in worker safety in Qatar are reflected in their changing epidemiology and incidence. Utilizing clinical databases are the first step to identify key risk areas and populations for targeted interventions that must be culturally and cognitively appropriate.

Creating partnerships with expatriate worker organizations and occupational safety professionals may be another step to enhancing the effectiveness of worker safety programs in Qatar. A nationally linked WRI database will be essential to provide data to guide the prioritization and formulation of future program, as well as the evaluation tool to monitor their performance and effects on worker safety.

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Ensuring contract worker safety in complex organizational systems

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ABSTRACT: A decade ago, high reliability researchers suggested that organizational interfaces are areas that pose a challenge for effective safety management (Bourrier, 2005). Outsourcing tasks to external contractors creates new interfaces that then require careful management to ensure worker safety is not jeopardized. Whilst contractor management has long been one area of focus in corporate safety management systems, the trend to outsourcing increases the importance of efforts to effectively manage relationships across the myriad of new organizational boundaries this mode of working creates. This paper describes our work on a tool to support contractor management in the aviation sector in the form of a safety culture maturity scale (after Parker et al., 2006) which addresses contractor relationships in some detail. The tool provides a series of questions covering five phases of contractor management (planning, capability assessment, post award, performance monitoring and contract close out). For each question, users are invited to choose what best describes their company's systems and behaviours from short descriptions of five stages of organizational safety culture development (pathological, reactive, bureaucratic, proactive, generative). It is supported by an action plan which provides organizational advice on moving from one stage to the next. Drawing on high reliability theory, safety management system principles and interviews with airline and contractor personnel, the tool addresses organizations that seek to use contractor services in any form from specialist services to labour hire to project work. The aim is to assist in improving contractor relationships and as a result, contract worker safety, by allowing organizations to assess where their current practices fall on the scale and so what they might need to do to improve. The importance of better tools for contractor management is not confined to the aviation sector. This tool has broader application that we are seeking to test in a range of sectors.

1 INTRODUCTION

Worldwide, the aviation sector has seen increasing trends towards outsourcing and the use of contractors (Jorens et al., 2015). While this practice delivers benefits to airlines with respect to operational cost and industrial relations, it brings with it potentially negative outcomes. With 243,000 people injured in 27,000 airport ramp incidents each year, airlines face a challenge in effectively and efficiently managing the work of disparate teams of contract workers in a hazardous environment while also focusing on their bottom line (Flight Safety, 2007).

This challenge is not confined to the aviation sector. To give this issue broader context, a recent study on the future of work notes that one in three workers in the US is now an independent contractor (Hajkowicz et al., 2016). Contractors may be used by organizations to:

- access specialist skills and staff,
- allow managers to focus on core operational activities,
- meet fluctuating workload, and/or
- minimise fixed costs. (Beale, 2003)

Notwithstanding the financial benefits such practices may provide to organizations, research shows that a reliance on use of contractors (also known as outsourcing) has important implications for workplace health and safety (WHS).

As Quinlan and Bohle (2015) point out, worker health and safety is one of the most profound effects of work itself. The way in which work is organized has a significant impact on the wellbeing of workers, their families and the broader community. This includes factors such as overtime, rates of pay and the precarity of employment all of which are impacted by employment practices such as outsourcing. As such, increasing trends to outsourcing of many functions previously seen as core business increase the need for a focus on how best to ensure worker safety.

Many organizations are aware that contractor management is a key function of effective safety management and yet tools to assist organizations in this area are scarce. This paper describes the development of one such tool that has as its primary goal assisting organizations that use contractors to consider how their practices and procedures support the safety of contractor workers as well as their own employees.

The paper continues with a description of the conceptual framework used in understanding why such a tool is needed and the general form it might take. Section 3 describes the tool development process and the empirical and theoretical foundations of the content of the tool. Section 4 gives examples of the content of the tool. The paper concludes with the planned next steps.

2 CONCEPTUAL FRAMEWORK

2.1 *Aviation safety*

While the public, especially those who fly commercially, might think about the safety of persons on planes as the principle area of concern for aviation sector health and safety, the ground itself is a very risky environment. From runway incursions to slips and falls on equipment and building/ground surfaces, an airport is an environment where persons are routinely injured and occasionally killed. The ATSB (2010), for example, has documented risks to both aircraft and personal through incidents involving collisions between aircraft, between aircraft and other vehicles, between vehicles and persons, as well as between persons and equipment and between persons and found object debris on runways, taxiways and aprons. Indeed, the ATSB (2010) noted 398 ground occurrences across the ten year period of their review. Forty one of these were closely inspected as they were serious enough to pose a risk to passengers or flight crew.

While incidents involving damage to aircraft and the potential loss of controlled flight capture the anxieties of the flying public, they in no way index the real, day-to-day risk(s) of injury or fatality faced by workers on the ground. Consider, for example, diverse hazards faced by ground workers on a daily basis. Schmitz-Felten (2014) outlined and summarised these as reproduced in Table 1.

Schmitz-Felten (2014, citing Lacagnina 2007) estimates that some 27,000 ramp accidents/incidents occur worldwide every year. These incidents injure more than 240,000 persons representing an injury rate of 9 per 1,000 departures. Schmitz-Felten (2014, citing Chamberline et. al., 1996), indicate that while injury events occur anywhere within the boundaries of airports, turnaround events appear to index the greatest opportunities for injury. Forty three percent of all injury incidents take place at the gate stop and 39% at the gate entry and exit area. The remaining 18% occur outside the ramp entry area.

Of particular relevance here is that this work is largely carried out by contractors, rather than airline employees.

2.2 *Outsourcing*

Within contemporary airport operations, it is not inconceivable to envision nine different employers staffing the varied roles represented by workers outlined in Table 1 although in practice, however, some roles tend to be grouped together. This stands in contrast to recent practice in which one company might staff all the roles performed on and around aircraft. Dividing one employment role from within the central corporation to others outside it is commonly known as outsourcing. Quinlan (2013), citing Johnstone et al. (2001) and Nenonen (2011) defines outsourcing as:

> … the practice where a public or private organisation contracts another organisation or individual—usually through a process of competitive tendering—to undertake specified tasks, such as cleaning, transport or maintenance or even provision of a product. All or part of these tasks may in turn be sub-let to other parties—a practice known as subcontracting, or multitiered subcontracting when a succession of subletting of work occurs. Subcontracting is not a new practice for organising work. Indeed, subcontracting and multi-tiered subcontracting has long been common in some industries, like construction and road transport. However, over the past 30 years these practices have become more pervasive across a wide range of industries, including aviation. (p. 284)

Indeed, aviation appears one sector in which outsourcing is an increasingly popular business practice. Airports United (2016) has documented an accelerated shift towards the employment of contract ground handling workers. Airports United projects that by 2020 nearly 60% or ground

Table 1. Airside operations and injury risks for ground staff* (after: Schmitz-Felten, 2014, p. 4).

	Examples
Work organizational	stress, shift work, night work, working to tight deadlines
Physical work factors	noise, adverse weather condition, exposure to sun, lightning, vibration, working outside
Dangerous substances	exposure to de-icing chemicals, jet fuel and exhaust, substances used for maintenance, cleaning agents, biological agents (faeces and sewage)
Ergonomic factors	working in awkward position, heavy loads, confined spaces
Accidents	falls from height, slips, trips and falls, electrocution, vehicle accidents, hit by falling or moving objects, fires and explosion, inappropriate or defective equipment, inadequate lighting

*Ground staff includes ramp agents, aircraft marshaller, baggage and cargo handler, refueller, de-icer, push back crew, toilet servicing—draining of the aircraft waste system, maintenance and repair personnel and cleaners and caterers.

handling will be accomplished by contract workers. Today, this figure sits at 40%. As Airports United notes further, the use of contract workers has reaped handsome rewards for airlines. While passenger numbers have grown in recent years, labour costs for ground handling have declined 5.5% between 2014 and 2015 alone.

The airside environment of today's airports is an intertwined welter of risks, responsibilities, costs, and opportunities for improvement. The immediate takeaway from the study of contemporary airline operations is that the ground is a challenging environment for both workers and their managers. While outsourcing instantiates multiple relationships between worker and corporation, the question of what burden this represents for the employing agency remains an open one.

Outsourcing is a practice of interest to those studying organisational coherence because the distribution of processes and procedures from within one central, unified, stream of work into external distributed pieces may give rise to what is known as disorganisation of work. Quinlan et al. (2013) provide a summary of this topic:

> The fracturing of tasks into separate contractual units, which invariably contributes to a greater level of work disorganisation, not only because chains of command are now more complicated, but also because the new units frequently cut across the informal and formal rules and understandings that govern workplace behaviour. For example, contractors and their employees may be unaware of the many pieces of informal knowledge used by regular workers to avoid hazardous situations or the consequences of apparently harmless acts on other workers. Disorganisation can also result from cuts to staffing levels and reduction in the level of qualified personnel. (p. 285).

In other words, the introduction of a new division of work into smaller pieces while conducted within reference to the larger contracting organisation's priorities and practices instantiates a discontinuity of organisational rules, practices, and priorities. McDermott and Hayes (2016) note the typical corporate adjustment to managing safety in a complex contracting supply chain may lead to a focus on procedural compliance at the expense of nurturing safe worker behaviour. They also indicate when such a shift in the contracting and delivery of work is thus re-organised, it is the worker themselves which become "increasingly responsible for the costs associated with their own safety" (p. 9) as decisions trading of time/cost and safety are made at the bottom of the subcontracting chain.

Despite attempts to shift responsibility down the subcontracting chain by defining relationships in contractual form, Australian workplace health and safety legislation does not permit safety to be treated in such a fungible manner. Current legislation avoids use of terms such as employer and employee and instead focuses on the duties of a person conducting a business or undertaking (PCBU). Specifically 'a PCBU has a duty to ensure, so far as is reasonably practicable, the health and safety of workers.' (Tooma, 2013, p. 9) This includes workers who are not specifically employees but rather all those whose work is influenced or directed by the PCBU. In the case of outsourcing, multiple prosecutions have illustrated that duties extend through the supply chain.

Research has shown that contractor safety is a key issue worthy of further applied research attention.

2.3 *Self-assessment tools*

Both the academic and industry-based safety literatures include many tools that organizations can use to assess the state of safety in order to seek areas for improvement. A review of the literature (Hayes & Zhang, 2016) suggests that many safety self-assessment tools mention contractor management as important for safety but that there is nothing sophisticated that focuses specifically on this subject.

Broadly speaking, safety self-assessment tools take a wide range of forms including checklists to be applied by subject matter experts, employee surveys and questions aimed at generating reflection. The theoretical underpinnings of such tools regarding what it takes to ensure excellence in safety performance vary from a purely management system approach to safety culture, high reliability organizations theory and resilience engineering. Other tools are based on industry experience in specific sectors.

The tools are all broadly designed to produce results that can be tracked over time or compared across organizations to benchmark an organization's performance against others in order to gain a sense of whether process safety performance is improving. Some tools are based on surveys of employees that measure perceptions (rather than concrete facts). Other tools are designed to be used by an expert auditor/investigator to review company policies, procedures and practices in a targeted way.

It must be recognized from the outset that all the self-assessment tools only provide results in the form of a 'snap shot' of the current state of the system (i.e. what is happening) without necessarily highlighting the underlying reasons (i.e. why this has happened) or follow-up actions (i.e. how to make improvements). Assessment results simply provide a starting point to further explore the stories behind the numbers/results in order to determine appropriate improvement strategies.

This consideration of the form of available tools has suggested what we believe to be a reasonable way forward. We propose to produce a version of the Safety Culture Maturity Scale focused specifically on processes for managing contractors.

2.4 *Safety culture maturity*

To prevent accidents and ensure worker safety, the creation and nurturance of effective safety culture is essential. Reason (1997) famously proposed that an effective safety culture has four key characteristics namely:

- A just culture in which a high degree of trust exists between management and workers including clear definitions of acceptable and unacceptable behaviour and an acknowledgement that genuine errors sometimes happen. This encourages the second characteristic:
- A reporting culture which encourages all workers to report incidents and minor errors (in addition to accidents) without fear of unfair sanctions as the basis for organisational learning.
- A learning culture which is able to make use of small opportunities such as incident reports to reflect on the state of safety.
- A flexible culture which has the ability to cope with the constant change experienced by most organisations in the modern world.

A culture that promotes excellence in safety performance does not emerge fully formed but rather has to develop over time. Building on the work of Westrum (1992) and Reason (1997), Parker et al. (2006) developed a five-step scale describing how organisational safety cultures 'mature'. The five steps along with a summary of the prevailing management attitude at each step are:

- Pathological – "Who cares as long as we're not caught."
- Reactive – "Safety is important. We do a lot every time we have an accident."
- Calculative – "We have systems in place to manage all hazards."
- Proactive – "Safety leadership and values drive continuous improvement."
- Generative – "Safety is how we do business around here."

The Safety Culture Maturity Scale was originally developed in the offshore oil and gas industry (Parker et al., 2006) but has since been used in a variety of contexts to assess the extent to which an organization has a safety culture that supports high performance. Examples include the Minerals Industry Risk Management Maturity Chart (NSW Department of Industry and Investment, 2011) and the corporate safety governance pathway (IoDNZ and Worksafe NZ, 2016). The scale is grounded in an organizational view of accident causation where the actions of front line workers are largely determined by the way in which their workplace functions which is, in turn, determined by the priorities and processes set by senior management for the organization as a whole (Reason, 1997). Consistent with this view, the steps on the scale are characterized by management attitudes to safety which then determine the way in which all safety activities are carried out.

The changing attitudes up the scale indicate an increasing degree of management 'mindfulness' on safety issues consistent with the work of the high reliability researchers (Weick & Sutcliffe, 2001, Weick et al., 1999).

3 TOOL DEVELOPMENT

3.1 *Method*

Having settled on the safety culture maturity scale as the overall form for a tool that encourages organizations to self-assess their performance in contractor safety management, the development of the tool comprised three steps:

- develop a list of relevant aspects of contractor safety management,
- identify what processes and practices look like at each stage of maturity for each aspect, and
- develop advice for organizations on how to improve, based on their current performance according to the tool.

The outputs of the first two steps form a matrix against which organizations can self-assess. Depending on the result, the last step provides advice for improvement. At all stages, the development of the tool has been driven by both literature review and empirical work as described below.

3.2 *Empirical work*

Development of the tool was informed by empirical work regarding contractor management practices in a major airline. Fieldwork was designed to address two research questions:

1. How is worker safety, across the airline, impacted by the current internal and external supply chain?
2. How can internal and external supply chain management be improved to facilitate better worker safety outcomes?

Fifty one people were interviewed in total from two key groups. The first group of interviewees was made up of 23 office-based personnel with roles in corporate management, procurement and safety. The second group of interviewees comprises 28 individuals working as ground handlers across seven airports. Interviews were recorded (with permission) and transcribed before being subject to thematic analysis using NVivo software. Key findings of direct relevance to contractor safety management and so development of the tool were made in three areas.

3.2.1 *Work as imagined and work as done*

The empirical work emphasizes the importance of processes that can align work as imagined (as written in procedures) and work as done (actual field practice) (Hollnagel, 2015). In this airline, we found that head office based management and safety professionals underestimated the degree of variation involved in tasks undertaken by contract ground workers as a result of local environmental factors.

Workers need to make on-the-run adjustments to standard ways of doing things to take into account differences in aircraft type and airport layout but also time pressure and other dynamic environmental factors. Such adjustments appear to be largely opaque to those higher up the supply chain, impacting their understanding of key hazards and risks.

3.2.2 *Compliance and bureaucratization*

As a result of the incomplete understanding of the level of necessary variation in work practices, the general contention of office-based staff was that contractor safety could be best assured by a strong focus on compliance with standardized company procedures. Assertions that safety was best achieved by such bureaucratization was a claim that could clearly be contested when taking into account the "real conditions under which safety is produced" (Bourrier & Bieder, 2013, p. 3).

This empirical finding sits well with the safety culture maturity scale which includes a calculative approach with a strong system focus as the third of five stages. Compliance with procedures for its own sake is not a sufficient safety strategy.

3.2.3 *Trust*

This airline has a safety culture that is significantly oriented towards hazard reporting for both workers and contractors. Interview data revealed both the willingness of contract workers to report hazards and the extent to which some workers felt their contribution was valued as they had generally received feedback. The data also reveals the fragility of the trust between contract workers and the client organization as other workers told us that their concerns were apparently ignored and workplace hazards, in some cases, remained unaddressed.

These three fieldwork findings have informed the content of the self-assessment tool.

3.3 *Question development*

Bearing in mind that the tool is designed for self-assessment, in developing the questions, we have chosen to focus on what Parker et al. (2006) call the concrete aspects of safety culture maturity. These are the policies, procedures and work practices that result from the underlying values and attitudes of the organization.

Based on a review of the literature regarding contractor safety management practices, the overall structure of the question set consists of five interlinked stages:

- Planning
- Capability Assessment
- Post award
- Performance monitoring
- Contract close out.

These stages correspond to the typical management system steps of the typical Plan-Do-Check-Act cycle (Deming, 2000) with the addition of a contract close out stage.

A set of 25 questions have been developed across these stages reflecting processes, practices and relationships targeting a client organization's expectations from outsourcing itself and from particular contractors.

3.4 *Descriptions across five cultural stages*

Parker et al.'s (2006) work on safety culture maturity addressed contractor management as one of eleven concrete organizational aspects of safety culture in practice. Their original descriptions of contractor management are reproduced in Table 2.

This framework for safety has been expanded dramatically in our self-assessment tool into descriptions of the concrete procedures and practices in place for each safety culture maturity step for each of the areas highlighted by the 25 questions. The descriptions

Table 2. Safety culture maturity and contractor management (reproduced from Parker et al. 2006, Figure 2).

Safety culture level	Contractor management
Pathological	Get the job done with minimum effort and expense.
Reactive	The company only pays attention to HSE issues in contracting companies after an accident. The primary selection criterion is price, but only poor safety performance has consequences for choice of contractor.
Calculative	Contractors meet extensive pre-qualification requirements, based on questionnaires and statistics. HSE standards are lowered if no contractor meets requirements. Contractors have to get up to speed on their own.
Proactive	HSE issues are seen as a partnership. Pre-qualification in on the basis of proof that there is a working HSE-management system. Joint company-contractor safety efforts are observed and the company helps with contractor training.
Generative	No compromises to work quality. Find solutions together with contractors to achieve expectations even if this means postponing the job until requirements are met.

were developed drawing on Parker's work informed also by Reason's four key characteristics of an excellent safety culture and HRO principles (Weick et al., 1999) regarding the benefits of diversity of views, the importance of learning from small failures, the value of situational awareness, the benefits of letting decision making align with expertise and the value of multiple defenses and resilience. In addition, we have considered sociological questions of organizational power and risk shifting (McDermott & Hayes, 2016).

The cells describe various states of contractor management and so will allow organizations to judge where they 'sit' on the safety culture maturity scale (from pathological to generative) regarding each management system stage (from planning to contract close out).

3.5 *Strategies for improvement*

The concrete or tangible safety issues addressed in the self-assessment tool are issues that will be readily apparent to those in the organizational system (whether in the client organization or through the contractor chain). In that way, it is relatively straightforward for people to judge where their organization 'fits' on the safety culture maturity scale on each issue if they have knowledge of current practices. This is not the same as being able to see how to improve performance on each issue.

Moving from one step on the ladder to the next is not simply a matter of writing new processes or procedures. The tangible safety practices described in the tool are manifestations of underlying organizational attitudes regarding what makes for a safe workplace. As described above, safety culture is significantly a top down phenomenon and so moving across the matrix from one safety culture maturity step to the next requires changes in management attitudes as well as having the systems and processes in place to effect such a change in practice. In order to move up the maturity scale and change safety outcomes it is these factors that need to be brought into the open, examined and ultimately changed.

To assist users of the tool, we have compiled more detailed descriptions of the safety culture at each step on the ladder, highlighting the differences at each step particularly in relation to management attitudes to safety and communication about safety throughout the contractor chain. This information provides management and professional safety staff with advice on how to move from one step to the next.

4 SELF-ASSESSMENT TOOL CONTENT

It is beyond the scope of the paper to provide readers with the full tool although we are pleased to provide some examples here in the form of one question from each of the five stages of contractor safety management we have addressed, starting with planning.

The first issue in planning for outsourcing is to decide what tasks can appropriately be undertaken by contractors. Organizational attitudes towards this issue therefore form the first question in the self-assessment tool as shown in Table 3.

The second stage of contractor safety management is capability assessment. Questions in this stage cover contractor selection and assessment of safety capability and include questions about establishing a relationship with contractors that fosters good safety performance. One of the key questions in this stage is shown in Table 4.

The biggest part of the tool relates to the post-award stage or the operational phase of contractor/client activities. This stage includes questions regarding operating procedures, standards, risk assessments, site inductions, sharing safety information, ongoing competency, hazard reporting and job safety techniques. A sample question is shown in Table 5 regarding day-to-day management of change.

The fourth stage of the tool is about processes and practices for performance monitoring. Questions are included about auditing and incident reporting, analysis and feedback. The sample question shown in Table 6 addresses how organizations monitor contractors' day-to-day safety performance.

The last stage of the tool is contact close out and comprises the question shown in Table 7.

Table 3. How do we decide what activities are done by contractors?

Safety culture level	Contractor management
Pathological	Cost is the driving factor. If it's cheaper to outsource, we will do so. Safety is seldom considered.
Reactive	Cost is the driving factor. We use both labor hire and technical specialist contractors. Contractors activities are quite separate from work done by our own people and even labor hire contractors are treated differently to our workers on a day to day basis.
Calculative	We contract out work where clear job expectations can be assigned to contractors. We recognize if we are 'supervisors' (individual contractors who work within our teams) or 'active clients' where we hire organizations to complete tasks.
Proactive	Expertise is an important factor. We contract out specialist work and aim to learn from our contractors in a true working partnership.
Generative	Expertise is the driving factor. We contract tasks that others can do better and more safely than we can. At a working level, contractors are treated the same as our own workers.

Table 4. What contractual incentives are contractors given to ensure that their workers are working safely?

Safety culture level	
Pathological	We pay our contractors for the work they do. There are often financial penalties for production failure, potentially in conflict with safety.
Reactive	Contracts include penalties for poor safety performance outcomes. Rewarding positive behavior is not common.
Calculative	Safety performance is said to be important. Reporting of incidents is required in the contract. Contracts may include specific incentive payments linked to injury statistics and other lag measures. There may be other safety awards such as stubby holders and baseball caps.
Proactive	Good safety performance is rewarded and considered in performance reviews. Contractor performance appraisal is based on carrying out the right processes as well as (not) having incidents
Generative	Finance is directly involved in discussions about how to incentivize contractors to achieve all operational performance goals including safety. Recognition of good safety performance is seen as being of high value.

Table 5. How is day-to-day management of change (MOC) impacting contractor's activities handled?

Safety culture level	
Pathological	We believe that change is necessary to get the job done. We don't draw attention to it unless it has an immediate financial impact. There is no system for contractors to report changes in process to us.
Reactive	MOC is seen as necessary because of a history of incidents and inefficiencies, but is very simplistic mainly involving equipment, rather than processes or issues linked to people and the way work is done. Contractors should tell us when they are making changes.
Calculative	There are formal processes for reporting, identifying and managing change, often triggered by cost thresholds rather than risks. If contractor activities trigger the MOC process, then they are considered in this context but many contractor changes bypass the trigger. The MOC follows a fixed process that helps search for unintended consequences but is limited within preset parameters. Change is seen as a pain that has to be endured.
Proactive	Change is treated as making things efficient and there is the realization that change is inevitable so has to be checked for regularly. MOC is supported by processes to identify complex interactions including with contractors' systems of work. The MOC process is triggered by risk criteria.
Generative	The organization embraces change as allowing competitive advantage. As change is perpetual MOC is inherent in design and planning processes and communicated to all departments and contractors.

Table 6. How do we monitor contractors' safety performance day to day?

Safety culture level	
Pathological	There is no formal system for checking for safety problems on a daily basis and no informal observation. Individuals are supposed to take care of themselves.
Reactive	There is a reliance on management at the contractor to spot their own problems. Superficial checks may be performed by line supervision/management when they are visiting, mostly after incidents or inefficiencies. There is no formal system for follow up.
Calculative	Site activities including those done by contractors are regularly checked by the line for safety issues, but not on a daily basis. Inspections aim to check that procedures are being followed.
Proactive	Supervisors encourage work teams throughout the contractor chain to check safety issues for themselves. Managers from all levels on the chain doing walk-rounds are seen as sincere. Internal cross-inspections, i.e. between contractors, take place, involving managers and supervisors.
Generative	Everyone checks for safety hazards, looking out for themselves and their work-mates including those who happen to be contractors. Supervisor inspections are largely unnecessary.

Table 7. What happens when a contractor finishes working with us?

Safety culture level	
Pathological	Nothing in particular. We just stop paying them.
Reactive	We send contractors a close out form letting them know how we feel they performed. It might mention their safety injury record.
Calculative	We like our contractors to complete a substantial set of close out paperwork recording concrete safety statistics and audit close out items. We might have a meeting to discuss.
Proactive	Contract close out meetings are an established practice. We try to allow space for feedback from the contractor on our performance as well as the other way around.
Generative	We appreciate this might be our last opportunity to get insights from our contractor on how safety could be improved. We aim to make the most of that with a comprehensive set of frank contract close out discussions involving management and workers.

These five sample questions from a total of 25 included in the self-assessment tool overall illustrate the overall approach used, particularly the focus on concrete aspects of practice that are the heart of the design.

5 CONCLUSIONS AND NEXT STEPS

Contractor safety management is an increasingly important facet of worker safety in modern organizations due to the rise of outsourcing. Despite this, few tools are available for organizations who seek to benchmark their practices against key safety principles from the research literature.

This tool aims to fill that gap. The content has been validated against the literature and by comparison with key contractor safety management issues in one major airline.

The intention is to continue further field testing of the tool with a view to making an online version freely available via the web site of an Australian workplace safety regulator.

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Potential safety influences of communication and language difficulties at sea: A comparison of vessels with and without multinational crews

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ABSTRACT: The aim of the present study is to examine the potential influences of communication and language difficulties for maritime safety. The study is based on: 1) Literature review, 2) Qualitative interviews with 10 sector experts and 3) Small-scale survey (N = 222) among seafarers working on ships operating from Norway, registered in NOR, NIS and Flags of convenience (FOC). The literature review indicates that communication and language difficulties may be an important factor influencing maritime safety, and that this may be a main drawback of mixed nationality crews. The survey indicates that respondents on board mixed-nationality vessels experienced more unsafe situations because of language misunderstandings between different nationalities on board.

1 INTRODUCTION

1.1 *Background*

Cabotage at sea refers to maritime transport between ports within a country. Since the 1970s the transport of goods by ship has been increasingly internationalised, and foreign actors can legally conduct cabotage, both in Norway and in other maritime nations, given some exceptions such as the U.S.

The international character of shipping is reflected in Norwegian and other waters by the presence of vessels associated with different flag states, different operator states, and with multinational crews. (Here the flag state is the nation where the ship is registered, to which taxes are paid and whose regulations are followed, whereas the operator state is the home nation of the shipping company or operator.)

Alderton & Winchester (2002) suggest that the maritime industry is not only central to world trade, it is also the only example of a fully globalized industry.

It is not unusual that the vessel, owners, operators, shippers, charterers, insurers, the classification society, officers and the crew are all of different nationalities (IMO 2008, in Liang 2011: 3). These complex constellations offer several challenges to safety management and regulation.

Vessels flying the Norwegian flag can either be registered in the Norwegian Ordinary ship Register (NOR), or the Norwegian International Ship Register (NIS). NOR is the register for ships with a Norwegian basis, which mainly carry out transports within Norway or to or from Norway. NOR registered vessels must adhere to Norwegian rules on working conditions and wages (St. melding nr. 31 2003–2004). This may however increase operational costs and reduce ships' abilities to compete with foreign ships.

As a consequence, NIS was established in 1987, in order to improve the competitive abilities of Norwegian ships sailing abroad (St. melding nr. 31 2003–2004). Several traditional maritime states (e.g. UK, France, Denmark) have established so called "second registers" providing more lenient framework conditions than the national registers, in order to prevent national shipping companies from flagging out (Roberts, Marlow and Jaremin 2012). One of the main advantages for owners of NIS registered vessels compared with NOR registered vessels is that the former are permitted to pay foreign crew members in accordance with the wage level of their respective home countries. FOC, also called "open registers", constitute a separate type of flag state. Flagging vessels out to FOCs has become widespread in recent decades, as FOCs provide the opportunity to avoid strict regulations (e.g. on wage and working conditions) and high taxes (Zwinge 2011; Fan et al. 2014; International Transport Workers' Federation 2012). In 2012, the International Transport Workers' Federation defined 34 countries as FOC states. The maritime industry has seen an increasing internationalisation in recent decades, indicated by a steady rise in vessels being flagged out to FOCs.

The domestic transport of goods at sea in Norway is open to foreign actors, and port statistics show an increase in cargo transported by ships flying flags of convenience, and a sharp reduction in cargo carried by Norwegian registered vessels in the period 2003–2012 (Nævestad, Caspersen, Hovi, Bjørnskau & Steinsland 2014). Vessels flying flags of convenience account for the largest proportion of transported cargo in the 30 largest ports in Norway over recent years.

In 2005 it was reported that 50% of the total crew of 35,000 on board Norwegian-registered vessels were foreign citizens, mostly from the Philippines, India, Poland or Russia (Håvold, 2005). It is important to establish whether the increased presence of ships flying flags of convenience and foreign crew members in Norwegian waters have safety implications, in order to implement mitigating measures if necessary. In particular, vessels flying flags of convenience are largely manned by multinational crews comprising seafarers with different languages, national safety cultures and wage and working conditions than Norwegian seafarers. International research asserts that approximately two-thirds of all ship crews are now multinational (Hetherington, Flin, & Mearns, 2006). It is therefore important to assess safety implications of diverse culture, varying communication abilities and working conditions on board ships in Norwegian waters.

1.2 *Aims*

The aim of the present study is to examine the potential influences of communication and language difficulties for maritime safety.

1.3 *Safe foreign transport*

The study is part of a larger research project, aiming to assess the effect on accident risk of the increasing shares of foreign actors in road and sea transport of goods in Norway; and to provide a scientific knowledge base that Norwegian authorities can use to develop measures to reduce any increased risk identified. Information on the project: «Safe Foreign Transport» (SAFT) can be obtained on the website: www.toi.no/SAFT. The project is funded by the TRANSIKK program of the Norwegian Research Council. The present study discusses the only risk factor which was found to be important in a report on risk factors related to increasing internationalization at sea (Nævestad 2016). Thus, the data that the present paper is based on are collected for this larger study, also focusing on national culture, working conditions and fatigue, rules, implementation and enforcement

2 METHODS

2.1 *Literature review*

A literature search was conducted, aiming to: 1) Examine safety outcomes of internationalisation in maritime transport, 2) Discuss the importance of potential risk factors and 3) Discuss potential measures to increase maritime safety further.

Although initial searches were done throughout 2014 and 2015, the final systematic literature searches were conducted in November and December 2015. The searches included four scientific online libraries: Sciencedirect, Ovid, Google Scholar and Trid. General searches in Google were also conducted.

The searches in the scientific databases included a combination of the following terms "nationality" and "maritime safety", "flag state" and "safety", "open register" and "maritime safety", "nationality" and "shipping accidents", "flags of convenience" and "safety", "mixed nationalities" and "safety", "nationality" and "safety in shipping". Some of these key terms were also translated into Norwegian, to search for documents written in Norwegian.

When possible, for instance in the "Sciencedirect" searches, we searched for these terms in the "title, abstract and key words" of scientific papers for all years. The titles of publications generated were read, and when titles were considered relevant the abstracts of the publications were also read. Finally, the literature search was also supplemented by research literature that we already knew about, and which we perceived as relevant to the aims of the study. These were not uncovered by the searches. All in all the literature search generated 20 studies that were relevant to at least one of the three aims of the study.

When reviewing the studies on risk factors and potential measures, we focus less on reviewing the methods and approaches used by the study and more on what the studies may tell us about relevant risk factors, under which conditions these risk factors may be relevant, how the risk factors have been operationalized in surveys, and what kind of measures the risk factors would call for.

2.2 *Interviews*

We also conducted qualitative interviews with 10 sector experts from employer organisations, employee organisations, authorities and other organisations involved in maritime safety in order to gain knowledge on safety outcomes of increasing internationalisation, potential risk factors and relevant measures to increase maritime safety further. The interviews generally lasted for about 75 minutes.

We used a semi-structured interview guide (cf. Nævestad 2016), and the themes in the guide were influenced by results from our previous study (Nævestad et al. 2014) and the results from the literature study. The interview guide contained questions on the following risk factors: organisational safety culture, national safety culture, communication, competence and training, economy, manning level and competition long work periods and fatigue, technology and equipment, implementation and enforcement. The interview guide also contains questions on potential measures to address these risk factors, e.g. flag state enforcement, port state controls, targeting of substandard vessels, classification societies, improvement of communication skills.

The purpose of the interviews was to give us a deeper understanding of the context of relevant risk factors and safety problems, to give us insight into potential mechanisms that could shed light on different safety outcomes and the pros and cons of potential measures. This was also encouraged by encouraging interviewees to "think out loud" and assuring them that the purpose of the interview was to supplement the other data in our study. Thus, many of the suggestions in the interview data represent hypotheses and point to questions and issues that should be examined in future research.

We present the results from the interviews together with some of the results of a project reference group meeting which was held at The Institute of Transport Economics (TØI) March 27, 2014. Seven external participants were present at the reference group meeting, in addition to three internal researchers. The external participants were from authorities, employer organizations and employee organizations, insurers and research. We got important feedback, learned more about nuances within our research field, and got suggestions to further research. As we got many important view points and comments in the reference group meeting, we choose to also include some relevant highlights from this meeting together with the presentation of the interview results.

2.3 *Small-scale survey*

2.3.1 *Recruitment of respondents*

The respondents were both Norwegian and foreign seafarers and were recruited through "Kystrederiene", an employer organisation for Norwegian based shipping companies. Thus, all of the respondents work on ships that are operated from Norway, i.e. the shipping companies are located in Norway.

Web links to the questionnaires were distributed by "Kystrederiene" to all its members along with an introductory text explaining the purpose of the survey. The survey and the introductions were distributed both in Norwegian and in English (Nævestad 2016). In the introductory texts the shipping companies were asked to distribute the survey links to all employees working on ships. There were introductory texts in the beginning of each web survey, explaining the purposes of the surveys and stressing that the surveys were confidential.

2.3.2 *Survey themes and questions*

The surveys used in the original study (Nævestad 2016) included a total of eighty-seven questions on the following themes:

1. Background variables related to respondents: 7 questions.
2. Organisational safety culture: 18 questions.
3. Nationality, language, communication and safety: 9 questions.
4. Manning and fatigue: 19 questions.
5. Economy, efficiency, competition and safety: 5 questions.
6. Vessel characteristics and technology and safety: 6 questions.
7. Port calls and time pressure: 3 questions.
8. Competence, nationality and safety: 3 questions.
9. National safety culture: 7 questions.
10. Safety outcomes: 6 questions.
11. Risk analyses and procedures: 4 questions.

These key questions on nationality, language and communication are:

– How many different nationalities work on board your vessel?
– Approximately how many of your colleagues have a nationality that is different to yours?
– Have you experienced language misunderstandings between different nationalities on board?
– Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?"
– Have you experienced unsafe situations because of "cultural differences" between different nationalities on board?

A structured version of the survey, where items are related to the themes that they are supposed to measure, is presented in (Nævestad 2016). The items are in Norwegian, but available from the author in English on request. Many of the survey questions are from the study of Størkersen et al. (2011). And from a questionnaire developed by Safetec for The Norwegian Maritime Authority.

2.3.3 *Description of the samples*

We do not show the distribution of seafarers' gender, as there are only two female respondents in the sample. When we look at all the respondents, most (81%) work on NOR registered ships, 14% work on ships flying flags of convenience, while the remaining 5% work on NIS registered vessels. Table 1 also shows that 80% of the respondents are Norwegian, while the remaining 20% (N = 45) are foreign. Fifteen of these 45 foreign respondents were from Other Nordic countries, 3 were from Other

Table 1. Sums up the characteristics of our respondents and their vessels on key background variables.

	Age group	Position	Experience	Nationality	Register
1	Younger than 31 years	Captain	Less than one year	Norwegian	NOR
	26%	27%	4%	80%	81%
2	31–40	Deck officer	1–3 years	Other Nordic:	NIS
	20%	24%	8%	7%	5%
3	41–50	Deck crew	4–10 years	Other western EU	FOC
	27%	21%	23%	1%	14%
4	51–60	Chief engineer	11–15 years	Central Eastern EU –	–
	22%	7%	10%	9%	–
5	Older than 60 years	Engine officer/crew	More than 15 years	Asian	–
	6%	6%	56%	3%	–
6	–	Apprentice	–	–	–
	–	8%	–	–	–
7	–	Other	–	–	–
	–	6	–	–	–
Total	100%	100%	100%	100%	100%

Western European countries, 20 were from Central and Eastern European countries and 7 were from Asian countries. When we look at the different flag types, 9% of the NOR vessel respondents were foreign, 20% of the NIS vessel respondents were foreign and 84% of the FOC vessel respondents were foreign.

2.3.4 *Analysis of quantitative data*

We use Chi square tests to compare groups' scores on particular variables, if we for instance cannot compare means due to the variables' level of measurement. The chi square test tests whether the actual distribution of groups on a variable is statistically significant different from a coincidental distribution, or an independent normally distributed sample.

We use hierarchical, linear regression analyses, where independent variables are included in successive steps to examine respondents' answer to the question: "Have you experienced unsafe situations because of language misunder-standings between different nationalities on board?". The most basic independent variables are included first, e.g. age, sex, vessel type, position. Then the other independent variables are included. Of course, we cannot conclude about causality, as this is a cross-sectional and correlational study. We nevertheless use the term predict when we describe the regression analyses.

3 RESULTS

3.1 *Literature study*

The Norwegian Coastal Administration conducted a survey of maritime user needs related to e-navigation in October and November 2009. A total of 575 respondents participated in the survey, and 486 of these were seafarers and 72 were ashore operators. The majority of respondents were Norwegians or associated with Norwegian ship owners, but some respondents were from Sweden.

The seafarer respondents worked on a range of ship types including cruise-ships, tankers, cargo vessels, offshore supply vessels, fishing vessels and HSC. According to the Norwegian Coastal Administration, each of the operational areas of coastal, regional international and global oceanic transport are represented by at least a third of seafarer respondents each.

Results from the survey indicate that in communications between ships, 81% of respondents rated language skills as a problem to a high or moderate degree. In ship-shore communications, language skills were rated by 44% of respondents as a problem to a high or moderate degree. Thus, the Norwegian Coastal Administration conclude that respondents consider language skills to constitute an important challenge in maritime communications.

A survey conducted by the Seafarers International Research Centre (SIRC) at Cardiff University, based on analyses of more than 10,000 crew lists shows that only 1/3 of ships in the survey group were crewed with single nationality crews (Kahveci & Sampson, 2001). Thus, two-thirds of all ship crews are multinational. The authors report that about 25% of the ships had four or more nationalities.

Flag states require that each ship must have a working language that each employee must speak to a certain standard (Hetherington, Flin, & Mearns, 2006). In order to deal with the mixture of nationalities, the ships in Kahveci and Sampson's study generally used English as the stated common working language. However, research shows that far from all seafarers speak English fluently, and that this may have repercussions for maritime safety.

Presenting results of their comprehensive ethnographic study aboard fourteen ships, Kahveci & Sampson (2001) mainly focus on the issue of communication and the difficulties arising aboard the ships because of communication problems. Their research shows that on half of the fourteen ships that they studied, the stated working language (English) was a second language for everyone on board. They also give several examples of crew members speaking only in their own language, although this language was incomprehensible to other crew members. They also give examples of crew members with very poor English.

According to the seafarers that they interviewed, the main drawback of mixed nationality crews was communication difficulties. These difficulties affect several aspects of life aboard the ships. Kahveci & Sampson (2001) stress for instance the importance of good communication skills in order to avoid unintended offence, engaging in humour, avoiding social isolation and so forth. Moreover, they also found that miscommunication may have serious consequences for safety, and give examples to illustrate this, stressing that fluency in a common language underpins almost all social interaction on board multinational vessels, and increases the likelihood of the vessels operating as successful units.

In emergency situations with high cognitive demands it will be difficult to communicate effectively and coherently in a second language (Hetherington, Flin, & Mearns, 2006). Thus we may question the extent to which ratings, officers and harbour personnel in such crews can develop the common shared understanding required to meet the IMOs demand for an effective safety culture on board in which all seafarers "do the right thing at the right time in response to normal and emergency situations". The importance of language as a risk factor is uncertain, and we need more research on this.

3.2 *Results from interviews*

We asked the interviewees whether they have the impression that different mother tongues and poor English speaking skills among crew have consequences for safety on vessels in Norwegian waters.

Interviewees stated that this is likely to be a risk factor. It is important that you have a language in which everyone can communicate well, and which everyone is comfortable with. It is difficult to communicate in a language that is not your mother tongue, and this may lead to misunderstandings that may be negative to safety. Moreover, one interviewee also said that people may have inhibitions against asking one extra time to check that they have a correct understanding of what the other person said. It was therefore mentioned that measures aimed at improving the English-speaking skills of foreign crew members may be a good way of increasing maritime safety.

When we look at international regulations there is a requirement that the vessel must have a single defined working language. Safety communication should be in this language, which everyone is supposed to understand and be able to make themselves understood in. The maritime industry is global, and thus English is often defined as a working language. The level of English skills is very individual, and it also varies according to countries and regions, depending on factors like e.g. the quality of English education in schools in a country.

Interviewees stated that communication difficulties are sometimes named as a contributing cause in accident investigations. One interviewee stated, however, that communication difficulties can also be reported as a cause in accidents involving only Norwegian seafarers.

It was mentioned that Norwegian authorities do not have a well-developed tool for assessing the level of language skills in foreign crews. Inspectors use their English skills to initiate communication, and they then make a judgement about the language ability of the crew member.

As mentioned, one reference group member stated that research indicates that the composition of different national groups on board have important ramifications for safety culture. It seems that safety culture is better on vessels with crew members from one nationality instead of two nationalities, as a polarization between national groups may arise in the latter case.

3.3 *Results from small-scale survey*

We asked respondents: "How many different nationalities work on board your vessel?" There was a far greater national diversity reported by seafarers working on board FOC vessels than NOR vessels. A total of 94% of the NOR vessel respondents reported of "one or two nationalities", while the corresponding share on FOC vessel was 6%, and 84% 3–5 nationalities and 9% >5 nationalities. The numbers for the seafarers from NIS vessels are fairly similar to those of FOC vessels.

We also asked respondents: "Approximately how many of your colleagues have a nationality that is different to yours?" (cf. Figure 1). Results indicate that respondents on board NOR vessels largely work with people of their own nationality, while half of the respondents on board FOC vessels experience that at least half of their colleagues have a different nationality than their own.

A Chi square test shows that these differences are statistically significant at the 1%-level (P<0.001).

This is also reflected in the working languages used on board NOR and FOC registered vessels. Respondents working on board the FOC vessels all report that English is the working language on board, while only 13% of the respondents on board NOR vessels report English to be their working language. Eight of the ten respondents on board the NIS vessels report that English is the working language on board.

We asked respondents whether they have experienced language misunderstandings between different nationalities on board (Figure 2). We compare NOR vessels with FOC/NIS vessels in these analyses, as the latter registries have large shares of foreign employees and largely English as the working language on board.

Figure 2 indicates that respondents working on board FOC/NIS vessels experience more language misunderstandings, than the seafarers on board NOR vessels in our sample. A Chi square test indicates that the differences are statistically significant at the 1%-level.

We also asked respondents whether they have experienced unsafe situations due to language misunderstandings between different nationalities on board (Figure 3).

Figure 3 indicates that respondents working on board FOC/NIS vessels experience more unsafe situations due to language misunderstandings, than the seafarers on board NOR vessels in our sample. A Chi square test indicates that the differences are statistically significant at the 1%-level.

We also asked respondents whether they have experienced unsafe situations due to "cultural differences" between different nationalities on board (Figure 4).

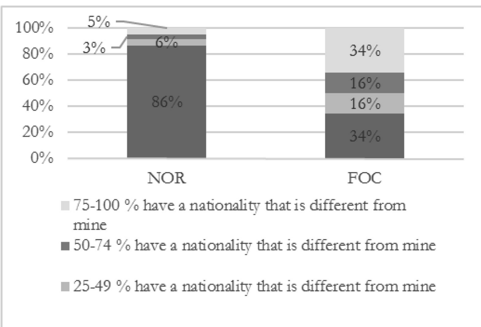

Figure 1. Respondents' answer to the question "Approximately how many of your colleagues have a nationality that is different to yours?". NOR (N=180), Flag of convenience (N=32).

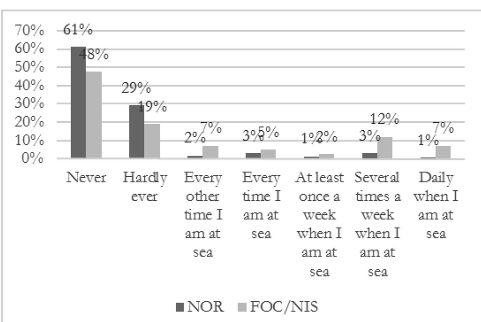

Figure 2. Respondents answers to the question: "Have you experienced language misunderstandings between different nationalities on board?" NOR (N=165), FOC/NIS (N=42).

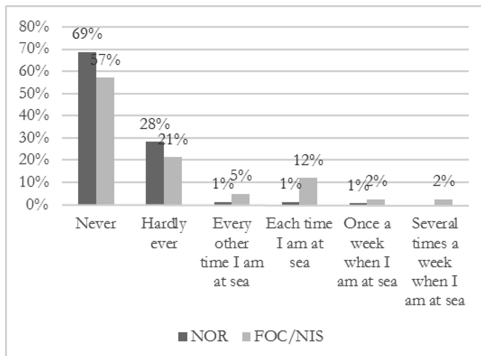

Figure 3. Respondents answers to the question: "Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?" NOR (N=166), FOC/NIS (N=42).

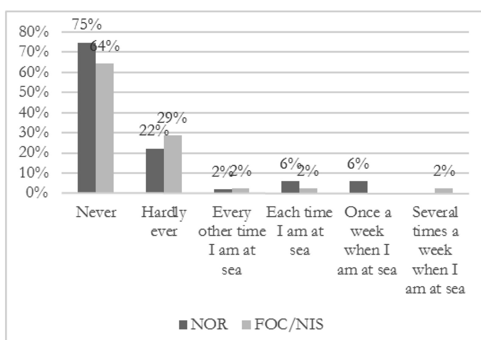

Figure 4. Respondents answers to the question: "Have you experienced unsafe situations because of "cultural differences" between different nationalities on board?" NOR (N=163), FOC/NIS (N=42).

It is hard to interpret the results of Figure 4. Results are inconclusive, the differences are not statistically significant.

3.3.1 *Which factors predict respondents' experiences of unsafe situations because of language misunderstanding?*

In Table 2 we show results from a hierarchical, linear regression analysis, where independent variables are included to examine factors predicting respondents' answer to the question: "Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?".

First, we see that respondents' age contributes significantly and negatively to their answers on the question: Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?". This indicates that, controlled for the other variables the older respondents are, the less likely they are to have experienced unsafe situations because of language misunderstandings.

Second, we see that vessels' manning level contributes significantly (at the 10%-level) and negatively, indicating that for each increased value on the manning level variable, the value on the unsafe situations because of language misunderstandings decrease with 0.150 points.

Third, we see that register contributes significantly (at the 1%-level) and positively, indicating that, controlled for the other variables, respondents on FOC/NIS vessels have 0.442 points higher score on the unsafe situations because of language misunderstandings variable. This is the most important predictor of unsafe situations because of language misunderstandings among the respondents.

Fourth, we see as expected that the share of colleagues with different nationalities contributes significantly and positively to the dependent variable. This indicates that, controlled for the other variables, the higher shares of colleagues with different nationalities that respondents have, the more unsafe situations because of language misunderstandings they experience. This is the second most important predictor.

Interestingly, we see in Step 8 that the contribution of register remains significant and considerable, when we take in the share of colleagues with different nationalities on board. Although we have seen that the number of nationalities are higher on board NIS and FOC vessel, this variable concerns the share of crew members with different nationality than the respondents, and not the actual number on nationalities on board the ships. It is important to note, however, that these variables are related.

Fifth, we see that nationality contributes significantly (at the 1%-level) and negatively. This indicates that Central Eastern European/Asian respondents have 232 points lower score than Norwegian/Nordic respondents on the unsafe situations because of language misunderstandings variable, controlled for the other variables in the model.

Finally, in Step 8, we see that the third most important predictor of respondents' answers to the question "Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?" is organisa-

Table 2. Linear. Dependent variable: "Have you experienced unsafe situations because of language misunderstandings between different nationalities on board?". The minimum value is 1 (Never) and the maximum value is 6 (Several times a week when I am at sea). The mean value is 1.5. Standardized beta coefficients.

Variables	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Age group	–0.078	–0.081	**–0.122***	**–0.124***	**–0.123***	**–0.146****	–0.102	**–0.138****
Vessel type (Other=1, Tank vessel=2)		0.089	0.081	0.088	0.088	0.030	0.022	0.031
Position (Other=1, Captain=2)			0.135*	0.142*	0.140*	0.061	0.064	0.043
Manning level				0.034	0.041	**–0.217****	**–0.163***	**–0.150***
Nationality (Norwegian/ Nordic=1 Central Eastern European/Asian=2)					–0.013	**–0.341*****	**–0.250*****	**–0.232*****
Register (NOR=1, FOC/NIS=2)						**0.648*****	**0.584*****	**0.442*****
Org. safety culture							**–0.248*****	**–0.239*****
Share of colleagues with different nationality								**0.252*****
Adjusted R^2	0.001	0.004	0.016	0.012	0.007	0.180	0.229	0.273

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Table 3. Bivariate Pearson correlations between unsafe situations because of language misunderstandings and other safety outcomes.

Variables	Pearson's R	P-value
Has the vessel been involved in a shipping accident (e.g. grounding, collision, contact injury, fire) in the two last years? (1–2) (Captains)	0.204	0.136
All in all, how do you assess the safety of your work place situation? (1–10)	–0.323	0.001

tional safety culture. This variable contributes significantly and positively at the 1%-level. For each increased vale on the organisational safety culture variable, the score on the unsafe situations because of language misunderstandings variable decreases with 0.252 points. Thus, good organisational safety culture seem to reduce respondents experience of unsafe situations because of language misunderstandings.

The Adjusted R^2 value is 0.273 indicating that the variables in the model explains about 27% of the variation in the dependent variable. Most of this is explained by the organisational safety culture variable, register and the share of crew members with a different nationality than yourself.

3.3.2 *Correlations between unsafe situations because of language misunderstandings and other safety outcomes*

The variable "Unsafe situations because of language misunderstandings" is a safety outcome in itself, as it refers to "unsafe situations". Respondents' definitions of "unsafe" may however vary, and it is therefore interesting to examine the relationship between this variable and other safety outcomes. In Table 3 we examine bivariate Pearson correlations between unsafe situations because of language misunderstandings and other safety outcomes.

Table 3 does not indicate a significant relationship between unsafe situations because of language misunderstandings and shipping accidents. The table does however indicate a significant relationship between unsafe situations because of language misunderstandings and respondents' assessment of the safety of their work place. This variable measures "risk perception". Thus, we may conclude that unsafe situations because of language misunderstandings is correlated to perception of risk on board but not accident involvement.

4 CONCLUSION

The literature review indicates that the main drawback of mixed nationality crews is communication difficulties. These difficulties affect several aspects of life aboard the ships. Good communication skills are needed to promote a shared implicit understanding among the crew, avoid unintended offence, avoid social isolation and so forth. More importantly, they are needed to prevent miscommunication, which may have serious consequences for safety. In emergency situations with high cognitive demands it will be difficult to communicate effectively and coherently in a second language. Interviewees also said that communication difficulties have been assigned as a contributing cause in several accident investigations, although this also applies to accidents on vessels with predominantly Norwegian seafarers.

The small-scale survey indicates a far greater national diversity reported by seafarers working on board FOC vessels than NOR vessels, and half of the respondents on board FOC vessels experience that at least half of their colleagues have a different nationality than their own. Respondents working on board the FOC vessels all report that English is the working language on board, while 13% of the NOR respondents do.

Results indicate that respondents working on board FOC/NIS vessels experience more language misunderstandings, including more unsafe situations due to language misunderstandings. We conducted analyses to examine the factors influencing respondents' experiences of unsafe situations due to language misunderstandings.

Results show that register was the strongest predictor. Respondents working on board FOC/NIS vessels were more inclined to experience unsafe situations because of language misunderstandings than NOR respondents.

Our analyses also showed that the second strongest predictor of experiencing unsafe situations because of language misunderstandings was the share of colleagues with different nationalities. The third most important predictor was organisational safety culture, indicating that good organisational safety culture facilitates good and safe communication.

Finally, bivariate correlation analyses did not find a significant correlation between experience of unsafe situations because of language misunderstandings and shipping accidents. We found a significant relationship between unsafe situations because of language misunderstandings and respondents' assessment of the safety of their work place.

When interpreting the results, it is, however, important to remember that numbers are small, and that communication and language difficulties was the only risk factor that was found important in a study comparing six risk factors in nationally flagged vessels and FOC vessels in Norwegian maritime transport (cf. Nævestad 2016).

Finally, it is important to note that communication difficulties among mixed nationality crews also may be due to "cultural differences", although our survey did not generate statistically significant results when asking respondents whether they have experienced unsafe situations due to "cultural differences". A previous literature review indicates that nationality could be an important source of culture in the maritime sector, particularly related to the national culture dimensions of "deference to authority" and the "value of the individual versus the group" (Nævestad 2017). The research literature on national culture indicates that it influences safety-relevant values, communication styles, methods of conflict resolution, decision making and organisational behaviour. The interviews supported this, indicating the importance of national safety culture for several aspects of maritime safety.

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Working conditions, fatigue and safety in Norwegian maritime transport

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ABSTRACT: The aim of the study is to examine the relationship between working conditions, fatigue and safety on vessels sailing along the coast of Norway. The study employs three methods: small-scale survey (N = 180) to crewmembers on NOR-registered vessels sailing along the coast of Norway, reference group meeting and qualitative interviews with sector experts (N = 10). The study indicates that respondents' opportunities to get sufficient sleep and rest on board, and demanding working conditions influence safety-compromising fatigue. Deck personnel were more likely to be fatigued in manners that may compromise safety. The study also indicates that having a good organisational safety culture decreases the risk of safety-compromising fatigue. Thus, future re-search should examine whether safety culture interventions could be developed to counter challenging working conditions and fatigue. The study focuses on the coastal cargo sector, and previous research and qualitative data suggest a high work load and thus more fatigue in this sector.

Respondents were asked to rate their agreement with the statement: "Sometimes I am so tired during working hours that safety is compromised". A total of 17% agreed somewhat/totally. Regression analyses showed that the older seafarers are, the less likely they are to report of safety-compromising fatigue. Second, deck personnel were more likely to be fatigued in manners that may compromise safety. Third, we found that having a good safety culture decreases the risk of safety-compromising fatigue. Finally, we found that respondents' experiences with demanding working conditions was the most important predictor of safety-compromising fatigue.

1 INTRODUCTION

1.1 *Background*

The research literature indicates that fatigue is an important safety risk in the maritime sector. Evidence is accumulating from international studies that fatigue is a problem for many watch keepers at sea. The Bridge Watch keeping Study of the Marine Accident Investigation Branch (MAIB) concludes a third of all the groundings involved a fatigued officer alone on the bridge at night (MAIB 2004).

Phillips, Nævestad and Bjørnskau (2015) review the research literature and interview experts to examine fatigue among watchkeepers at sea, and among transport operators in road and rail transport. They conclude that data on Norwegian accidents and incidents confirms that fatigue is an important safety risk in the maritime sector, but that we nevertheless lack quantitative data on the prevalence of fatigue among Norwegian operators.

Examining fatigue as a safety problem in shipping, Phillips (2014) sums up its main causes as: minimal manning level, port calls at different times of day, poor organisation, high demands on board, in addition to suboptimal watch systems contributing to unpredictable, fragmented and irregular sleep, and regular working through circadian lows. Other work characteristics influencing fatigue are for instance long working hours, sleep disturbances, due to for instance motion noise, and night work (Lützhöft, Thorslund, Kircher & Gillberg 2007; Allen et al., 2008). Studying the situation in Norway, Phillips et al. (2015) also conclude that the causes of operator fatigue are rooted in framework conditions, organisational factors and working conditions, as well as individual characteristics and life outside of work. Previous research has also pointed to relatively intense working patterns found in subsectors, e.g. coastal shipping (Starren et al., 2008; Smith et al., 2006). In terms of effort, coastal seafarers rated maintenance and loading tasks as highest, although navigation and watch keeping also required moderately high effort. Mini-bulker crew especially susceptible to fatigue, reporting twice as many fatigue symptoms as other ship types, and shoring worse reaction times and lapses of attention in a categorical search task (Smith et al., 2006). The Norwegian Maritime Authority (NMA) has previously identified challenges in the coastal cargo sector that may potentially affect safety, e.g. an ageing fleet, negative economic framework conditions (cf. Størkersen et al. 2011). In their study of this sector, Størkersen et al. (2011) especially point to the negative safety effects of fatigue, heavy workload and alienation, stressing that these factors may cause operational errors.

1.2 *Aims*

The aim of the study is to examine the relationship between working conditions, fatigue and safety on vessels sailing along the coast of Norway, focusing especially on coastal shipping. In the present study, working conditions is measured as a) manning level, b) port calls, c) a demanding working conditions index comprised of three items and d) whether respondents assert that they get enough sleep and rest on board. Organizational safety culture is also measured, based on an 18-item index. In our study, fatigue is measured by means of the question: "Sometimes I am so tired during working hours that safety is compromised". This question also provides our primary measure of the safety outcome of fatigue, as it refers to "safety compromising fatigue".

1.3 *Previous research*

There are many different definitions of fatigue, but many share the idea that it is a state caused by exertion (Phillips, 2015). Given this, a simple definition of fatigue is: "Fatigue is the body-mind response to sleep loss or to prolonged physical or mental exertion. "A similar but more comprehensive definition, explains the dynamic and multifaceted nature of the exertion that can cause fatigue (Phillips 2015):

> "Fatigue is a suboptimal psychophysiological condition caused by exertion. The degree and dimensional character of the condition depends on the form, dynamics and context of exertion. [This in turn depends on] the value and meaning of performance to the individual; rest and sleep history; circadian effects; psychosocial factors spanning work and home life; individual traits; diet; health, fitness and other individual states; and environmental conditions…"

In a broad review of the causes of fatigue, Phillips (2014) lists eight factors:

1. *Sleep and watch system.* Sleep is almost always studied in the context of a certain watch system. Research indicates that sleeps on two-watch ships (6/6) are rarely longer than 4.5 h, and sleep was also curtailed by those working a three-watch (4/8) system (Lützhöft et al., 2007). Participants on all watches had longer and better sleeps at home than while on board, and were also less sleepy and less stressed at home (Sanquist et al., 1997).
2. *Time of day.* Circadian variation of alertness with time of day has been studies in seafarers, and alertness found to be lowest at 0400 h (Knauth et al., 1986).
3. *Working hours and tour length.* The Cardiff Sea Study found working hours to be the strongest predictor of fatigue (Smith et al., 2003). Length of tour and working week have also been found to influence fatigue (Smith et al., 2003).
4. *Subsector.* As noted, previous research point to fatigue related challenges in maritime subsectors, e.g. coastal shipping, attributing it to intense working patterns (Starren et al., 2008; Smith et al., 2006).
5. *Psychosocial factors in the workplace.* Job demands, perceived stress and work support have been found to be selective predictors of fatigue, according to survey responses (Smith et al., 2003). According to logbook responses in the same study, fatigue was predicted by job satisfaction, job effort and sleep measures. Workload is a key type of job demand.
6. *Position.* Officers report more job demands and stress than ratings, but also more interest in job. The latter may explain why there is little difference in fatigue between the two groups, even though officers also report worse sleep quality (Smith et al., 2003).
7. *Age.* Age is an important predictor of fatigue-related symptoms; when operationalized in this way, fatigue has been found to increase with age (Smith et al., 2003). However, when operationalized as Need for Recovery, fatigue does not appear to depend on age (Bridger et al., 2010).
8. *Nationality/culture.* Lützhöft et al. (2007) found that non-Swedish participants rated their sleepiness lower, but reaction times were much slower. This suggests that there may be important cultural differences across nationalities which affect their perceptions of fatigue.

1.4 *Safe foreign transport*

The data used in the present report was originally collected in another project "Safe foreign transport", which is reported in Nævestad (2016a). The project was financed by the Norwegian Research Council's Transikk programme. The aims of the previous study were to study the relationship between organisational safety culture and safety on board vessels and to compare nationally flagged (NOR) vessels with vessels flying flags of convenience (FOC) when it comes to national safety culture, communication, working conditions, fatigue and implementation and enforcement of international rules (Nævestad 2016a). The present study looks closer at the sample of largely Norwegian respondents from NOR-registered vessels only (N = 180), to be able to consider the effects of organisational factors on fatigue without the confounding effects of flag or nationality (cf. Nævestad 2016b).

2 METHODS

2.1 *Interviews and reference group meeting*

We conducted qualitative interviews with 10 sector experts from employer organisations, employee organisations, authorities and other organisations involved in maritime safety. The interviews and the reference group meeting were conducted as part of the larger previous project reported in Nævestad (2016a-b) (cf. Chapter 1.4). The purpose of these interviews was therefore to gain knowledge on safety outcomes of increasing internationalisation, potential risk factors and relevant measures to increase maritime safety further. However, as the participants in the interviews and reference group meeting also provided rich and relevant information about safety culture, working conditions and fatigue in the NOR fleet of coastal cargo vessels that is the focus of the present study, this information is also included in the present paper (Confer Nævestad (2016a) for the interview guide). The interviews generally lasted for about 75 minutes. Useful information and viewpoints were also obtained in a reference group meeting held at the Institute of Transport Economics, March 27th, 2014, although the explicit focus of meeting was on the importance of flag state and crew nationality for safety. Results from this meeting are presented together with results from the interviews.

2.2 *Small-scale survey*

2.2.1 *Recruitment of respondents*

The respondents were recruited through an employer organisation for Norwegian based shipping companies, including more than 150 shipping companies and about 300 vessels. Thus, all the respondents work on ships that are operated from Norway, i.e. the shipping companies are located in Norway. Web links to the questionnaires were distributed by the employer organization to all its members along with an introductory text explaining the purpose of the survey, and stressing that the surveys were confidential. The shipping companies were asked to distribute the survey links to all employees working on ships.

2.2.2 *Description of the samples*

The distribution of seafarers' gender is not shown, as there are only two female respondents in the sample. Neither is the distribution of seafarers' nationality, as only NOR vessels are studied. Seven% of the 180 respondents are from another Nordic country, 1% are from another Western European country and 2% are from a Central/Eastern European country.

2.3 *Survey themes and questions*

The surveys used in the original study (Nævestad 2016a) included a total of eighty-seven questions on the following themes:

Table 1. Sums up the characteristics of our respondents and their vessels on key background variables.

	Age group	Position	Experience	Vessel type	Year vessel was built
1	< 31 years	Captain	<1 year	Bulk	Before 1980
	31%	28%	4%	34%	16%
2	31–40	Deck officer	1–3 years	General cargo	1980–1985
	17%	24%	9%	14%	8%
3	41–50	Deck crew	4–10 years	Tank vessel	1986–1991
	23%	20%	24%	4%	3%
4	51–60	Chief engineer	11–15 years	Well vessel	1992–1997
	23%	7%	7%	34%	16%
5	Older than 60 years	Engine officer	> 15 years	Stand by vessel	1998–2003
	6%	1%	56%	2%	14%
7	–	Engine crew	–	Anchor handling vessel	2004–2009
	–	4%	–	1%	23%
8	–	Catering	–	Fish farming vessel	2010–2015
	–	5%	–	6%	21%
9	–	Apprentice	–	Other	Before 1980
	–	9%	–	5%	14%
10	–	Other	–		–
	–	2	–		–
Total	100%	100%	100%	100%	100%

1. Background variables related to respondents: 7 questions.
2. Organisational safety culture: 18 questions.
3. Nationality, language, communication and safety: 9 questions.
4. Manning and fatigue: 19 questions.
5. Economy, efficiency, competition and safety: 5 questions.
6. Vessel characteristics and technology and safety: 6 questions.
7. Port calls and time pressure: 3 questions.
8. Competence, nationality and safety: 3 questions.
9. National safety culture: 7 questions.
10. Safety outcomes: 6 questions.
11. Risk analyses and procedures: 4 questions.

A structured version of the survey, where items are related to the themes that they are supposed to measure, is presented in (Nævestad 2016a). The items are in Norwegian, but available from the author in English on request. Many of the survey questions are from the study of Størkersen et al. (2011). And from a questionnaire developed by Safetec.

2.4 *Analysis*

When comparing the mean scores of different groups, we use one-way Anova tests, which compare whether the mean scores are equal (the null hypothesis) or (significantly) different. We use Chi square tests to compare groups' scores on particular variables, if we for instance cannot compare means due to the variables' level of measurement. The chi square test tests whether the actual distribution of groups on a variable is statistically significant different from a coincidental distribution, or an independent normally distributed sample.

We use hierarchical, linear regression analyses, where independent variables are included in successive steps to examine respondents' answer to the question: "Sometimes I am so tired during working hours that safety is com-promised". The most basic independent variables are included first, e.g. age, sex, vessel type, position. Then the other independent variables are included. Of course, we cannot conclude about causality, as this is a cross-sectional and correlational study. We nevertheless use the term predict when we describe the regression analyses.

3 RESULTS

3.1 *Results from interviews*

Reference group members considered fatigue and manning level to be among the most important risk factors in maritime transport. They stated that the small Norwegian ships sailing along the coast of Norway have low manning level, considerable work pressure and scarce time. Interviewees underlined that weariness and fatigue clearly are problems at sea, and that fatigue is mentioned in several accident reports, for instance describing people falling asleep on the bridge and then run aground. Fatigue is however hard to document in accident analyses. One interviewee stated that authorities cannot claim that vessels cheat with rest period lists, but said that they know that crew members often may work more than the rest period lists claim.

Administrative burden. Increase in the administrative burden was also emphasized in the discussion. This is due to an increase in formal authority requirements. Reference group members questioned the purpose of this, and rather suggested more measures to reduce the administrative pressure. The increase in administrative tasks has not been followed by an increase in available time on board. Thus, crew members have more work tasks that they must perform, and less time to rest. This means that the level of manning is not adapted to the work task. According to reference group members, this is largely a question of economy, which is essential for most.

Manning level. We asked interviewees whether there is a clear connection between manning level and safety. You cannot categorically say that safety on board increases with the number of people one interviewee said. For example, if there are too many people, they have too little to do and do not remain alert. However, with too few people on board there is a risk in and of itself. So you need to find optimal manning levels and even then they may vary with operational phase.

Tour length or watch schedule? Interviewees differed when it comes to whether the main factor behind fatigue at sea is the length of the period you stay on board or the daily watch schedule. A proponent of the first view, said that if you work for 12–13 hours a day for several weeks, it starts getting worrisome. We can all handle a hard session for two or three days, but after a long session, you are less alert. Unfortunately, we have no good tool to regulate the length of periods on board in our regulations, one interviewee said. The regulations only cover daily rest, which shall be a minimum of 10 hours—but there are no limits as to how long you can stay on board over time.

A proponent of the other view suggested that the watch schedules, i.e. the partitioning of the day into work and rest hours is what creates fatigue. Even within Norway there are great variations. What creates fatigue is the accumulation of a daily rest deficit. That usually happens with the 6–6 system, where you only get 4 hours of rest during each off duty period; you build up a rest deficit. No fatigue researchers claim that you cannot be on board for six months, this interviewee said. However, the social aspect of it, being away from friends and family makes being on board for six months problematic.

Type of transport. A third view on the causes behind fatigue suggested by one of the interviewees is that it is the type of transport that the vessel is involved in which creates fatigue. The number of port calls is a key variable in this respect, and whether crew members are given the opportunity to rest regularly in order to recover after work. If crew members have stressful work with few possibilities to recover, they are likely to be more fatigued after long periods on board. However, if crew members regularly are able to rest and recover it is less likely that they will be more fatigued after long periods on board.

3.2 *Results from small-scale survey*

3.2.1 *Rest on board*

Respondents were asked the following question on rest on board: "I get sufficient sleep and rest on board". Table 2 compares mean score for different groups on this question. The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree). The average score is 4.2

When we compare means for the statement "I get sufficient sleep and rest on board", we see that the only statistically significant differences are between respondents reporting of different organisational safety culture levels, indicating that vessels with good safety culture seem to be better at facilitating crewmembers' sleep and rest. Surprisingly, we see no significant differences, based on port calls or manning levels.

Table 2. Means on the variable "I get sufficient sleep and rest on board". The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree).

Value	Age group	Vessel type	Position/line of work
1 Score	Younger than 31 years	Bulk	Captain
	4.1	4.2	4.2
2 Score	31–40	General cargo	Deck personnel
	3.9	3.9	4.1
3 Score	41–50	Tank vessel	Engine personnel
	4.2	3.6	4.1
4 Score	51–60	Well vessel	Other
	4.3	4.3	4.3
5 Score	Older than 60 years	Other	–
	4.6	4.2	–
P value	0.564	0.478	0.819

3.2.2 *Working hours exceeding rules*

Respondents were also asked: "How often do you think your working hours exceed those laid down in the rules on work and rest periods?" A total of 27% answered "never", 49% "hardly ever", 24% of the respondents answered "at least every other time I am at sea", 10% "every time I am at sea", 3% "once a week when I am at sea", 5% "several times a week when I am at sea", while 1% answered daily when I am at sea.

Respondents were also asked to rate the agreement with the statement: "On this vessel we work more than we report that we do". A share of 48% totally disagreed with the statement, 12% disagreed somewhat, 14% answered 2neither/nor", 10% agreed somewhat, while 13% totally agreed 23%. Thus, we see that a share of 60% disagreed with the statement.

3.2.3 *Demanding working conditions*

Respondents were asked three questions on rest and working hours. We made an "Demanding working conditions index" of these questions. These questions are: "How often do you think that the following events happen while you are at sea?":

- Your shift change is delayed because of work operations, for instance port calls?
- You work more than 16 hours in the course of a 24-hour period?
- You are interrupted when you are off duty?

The following answer alternatives were available to the respondents: 1) Never, 2) Hardly ever, 3) Every other time I am at sea, 4) Every time I am at sea, 5) Once a week when I am at sea, 6) Several times a week when I am at sea, 7) Daily when I am at sea, 8) Do not know/not relevant. We made an index of these questions, by adding the three items.

Table 3. Means on the variable "I get sufficient sleep and rest on board". The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree).

Value	Port calls per week	Manning level	Organ. safety culture
1 Score	1–3	1–2 people	>70
	4	–	3.4
2 Score	4–6	3–4 people	70–75
	4.5	3.7	3.9
3 Score	7–9	5–6 people	76–80
	4.1	4.2	4
4 Score	10–12	7–8 people	81–85
	4.3	4.4	4.3
5 Score	13–15	9–10 people	86–90
	4.2	–	4.7
6 Score	>15	11–12 people	–
	3.8	–	–
P value	0.161	0.324	0.000

Answer alternative 8 "Do not know/not relevant" was excluded when we made the index.

Table 4 indicates significant differences (at the 10%–level) between respondents with different age groups and positions/lines of work. Respondents between 31–40 years old and captains experience more demanding working conditions.

Table 5 indicates significant differences between respondents with different scores on the organisational safety culture variable and on the manning level variable. Results indicate that respondents with low organisational safety culture scores experience most demanding working conditions. The same applies to respondents working on vessels manned with 3–4 people.

Table 4. Means on the demanding working conditions index. The minimum value is 3 (never) and the maximum value is 21 (daily when I am at sea).

Value	Age group	Vessel type	Position/line of work
1 Score	Younger than 31 years	Bulk	Captain
	6.5	5.9	7.3
2 Score	31–40	General cargo	Deck personnel
	7.5	6.2	5.8
3 Score	41–50	Tank vessel	Engine personnel
	5.9	7	6.2
4 Score	51–60	Well vessel	Other
	6.2	6.8	6.4
5 Score	Older than 60 years	Other	–
	4.3	6	–
P value	0.054	0.589	0.084

Table 5. Means on the demanding working conditions index. The minimum value is 3 (never) and the maximum value is 21 (daily when I am at sea).

Value	Port calls per week	Manning level	Org. safety culture
1 Score	1–3	1–2 people	18–69
	6.2	–	8.6
2 Score	4–6	3–4 people	70–75
	5.8	8.3	7.2
3 Score	7–9	5–6 people	76–80
	7.4	6.4	6.5
4 Score	10–12	7–8 people	81–85
	6.4	5.5	6.3
5 Score	13–15	9–10 people	86–90
	6.7	–	4.9
6 Score	>15	11–12 people	
	6.5	–	
P value	0.532	0.014	0.000

3.2.4 *Safety compromising fatigue*

Respondents were asked to rate their agreement with the statement: "Sometimes I am so tired during working hours that safety is compromised". A total of 17% agreed somewhat/totally. In Table 6 and 7

Table 6. Means on the variable "Sometimes I am so tired during working hours that safety is compromised" The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree).

	Age group	Vessel type	Position/ line of work	I get sufficient sleep & rest
1 Score	Younger than 31 years	Bulk	Captain	Totally disagree
	2.2	1.9	1.8	3.5
2 Score	31–40	General cargo	Deck personnel	Disagree somewhat
	2.5	2.2	2.3	2.9
3 Score	41–50	Tank vessel	Engine personnel	Neither/nor
	1.8	2.8	2	2.3
4 Score	51–60	Well vessel	Other	Agree somewhat
	1.9	2	1.7	2.5
5 Score	Older than 60 years	Other	–	Totally agree
	1.3	1.9	–	1.5
P value	0.039	0.282	0.088	0.000

Table 7. Means on the variable "Sometimes I am so tired during working hours that safety is compromised" The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree).

	Port calls per week	Manning level	Organ. safety culture	Demanding working conditions index
1 Score	1–3	1–2 people	>70	3–4 points
	2.1	–	2.7	1.4
2 Score	4–6	3–4 people	70–75	5–6 points
	1.9	2.3	2.6	2
3 Score	7–9	5–6 people	76–80	7–8 points
	2.1	2.1	2.3	2
4 Score	10–12	7–8 people	81–85	9–10 points
	1.9	1.9	1.9	3
5 Score	13–15	9–10 people	86–90	11–12 points
	1.9	–	1.4	3.1
6 Score	>15	11–12 people	–	13–21 points
	2.3	–	–	3
P value	0.705	0.315	0.000	0.000

Table 8. Linear regression. Dependent variable: "Sometimes I am so tired during working hours that safety is compromised".

Variables	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Age grp.	**–0.173**	**–0.179**	**0.154**	–0.151	**–0.155**	–0.085	–0.065	–0.044
Vessel type		0.099	0.079	0.075	0.050	0.038	0.015	0.019
Position			**0.157**	**0.159**	**0.158**	0.142	0.133	**0.193**
Port calls				0.045	0.034	–0.012	–0.028	–0.020
Manning lev.					–0.110	–0.051	–0.039	–0.003
Safety culture						**–<u>0.371</u>**	**–<u>0.256</u>**	**–0.183**
Sleep/rest							**–<u>0.344</u>**	**–<u>0.272</u>**
Dem. working conditions								**<u>0.244</u>**
Adj. R2	0.024	0.028	0.046	0.042	0.047	0.171	0.272	0.309

1 $p < 0.05$; **<u>1</u>** $p < 0.01$.

below, we compare mean scores for different groups on this variable. The minimum value is 1 (totally disagree) and the maximum value is 5 (totally agree).

Table 6 indicates significant differences between age groups and positions/line of work when it comes to safety-compromising fatigue. Older seafarers are less tired than young. Deck personnel are more tired than others. We also see that respondents who report to get sufficient sleep and rest on board report of less safety-compromising fatigue.

Table 7 indicates clear relationships between safety-compromising fatigue and organisational safety culture and between safety-compromising fatigue and respondents' experiences of demanding working conditions. Surprisingly, we see no significant differences, based on port calls or manning levels.

3.2.5 *Which factors predict respondents' experiences of safety compromising fatigue?*

In Table 8 we show results from a hierarchical, linear regression analysis, where independent variables are included to examine factors predicting respondents' safety-compromising fatigue. The dependent variable varies between 1 (totally disagree) and 5 (totally agree).

First, we see that respondents' age contributes significantly and negatively to respondents' safety-compromising fatigue in some of the steps, indicating that the older seafarers are, the less safety-compromising fatigued they are. Age ceases however to contribute significantly in Step 5.

Second, we see that position/line of work contributes negatively and significantly at the 1%–level to safety-compromising fatigue. This means that if you are deck personnel, you are more likely to be fatigued in manners that may compromise safety, when the other variables in the model are controlled for.

Third, organisational safety culture contributes significantly and positively at the 5%-level. This indicates that having a good safety culture decreases the risk of safety-compromising fatigue. It would be interesting to examine the mechanisms behind this relationship further. Step 7–8 give us hints about this.

The effect of organisational safety culture is reduced substantially, when the variable "I get sufficient sleep and rest on board" is included, indicating that the two variables are correlated. This could indicate that vessels with a good safety culture facilitate sufficient sleep and rest, and vice versa. Accordingly, we see that the effect of the safety culture variable is cut to half in Step 8, when the demanding working conditions index is included in the analysis. This index is the second most important predictor of safety-compromising fatigue. Given that this variable reduced the effect of organisational safety culture, we could assume that having a good safety culture involves preventing shift delays, 16-hours of continuous work and interrupted rests. More research is however needed to examine these relationships.

The variable "I get sufficient sleep and rest on board" is unsurprisingly the most important predictor of safety compromising fatigue. It contributes independently of demanding working conditions, although it seems correlated, as its effect is reduced when the demanding working conditions is included in the analysis. The Adjusted R^2 value in Step 7 is0.309, indicating that the variables in the model explains about 31% of the variation in the dependent variable.

4 DISCUSSION

Previous studies indicate that age is an important predictor of fatigue-related symptoms (Smith et al., 2003). However, with our operationalization of fatigue as "safety compromising fatigue", we found this to decrease with age, although it was only statistically significant in the first steps. This could indicate that older seafarers become better at dealing with job demands. More research is needed.

Previous research indicates that position (officers) influences fatigue (Smith et al., 2003). We found deck workers to be more fatigued than others, perhaps indicating that they have a high work load on the studied vessels

Previous research indicates that sleep and watch system influences fatigue in the maritime sector. We have not been able to examine this in the present study, as the 6–6 watch schedule was the most prevalent watch system among our respondents from all positions and lines of work on board (i.e. little internal variation in our sample). As noted, research indicates that sleeps on two-watch ships (6/6) are rarely longer than 4.5 h (Lützhöft et al., 2007).

Research also indicates that time of day and circadian rhythms influence fatigue. We have not been able to consider this in our study, as we use data from a project, which not primarily focused on fatigue.

Research also points to tour length as factors influencing fatigue (Smith et al., 2003). We have not been able to examine this in the present study, as our respondents generally stay on board for about four weeks with four weeks leave (i.e. little internal variation in our sample). Previous research indicates a certain adaptation to work demands over long tour periods. Interviewees suggested that if crew members have stressful work with few possibilities to recover, they are likely to be more fatigued after long periods on board. This has been found in previous research from the coastal cargo sector. For mini-bulkers, fatigue-related impairments have been found to increase rather than decrease as the tour progressed (Smith et al., 2006).

The Cardiff Sea Study found working hours to be the strongest predictor of fatigue (Smith et al., 2003). We have not measured this directly, but the qualitative data that the study is based on indicate that the respondents work in a sector with a high work pressure. Reference group members considered fatigue and manning level to be among the most important risk factors in maritime transport. They underlined the importance of challenging framework conditions in coastal cargo transport, suggesting that the small vessels transporting goods along the coast of Norway have low manning, considerable work pressure and scarce time. This may lead to too high workloads and fatigue, they suggested. Increase in the administrative burden was also mentioned as a fatigue-inducing factor in the sector. Accordingly, we found our demanding working conditions index to be the second most important predictor of safety compromising fatigue. This is in line with previous research, which has found job demands, perceived stress and work support to be selective predictors of fatigue, (Smith et al., 2003).

These working conditions seem to be due to the studied subsector, i.e. coastal cargo. Previous research points to fatigue related challenges in coastal cargo transport, attributing it to intense working patterns (Starren et al., 2008; Smith et al., 2006). Studying 10 Norwegian vessels, Størkersen et al. (2011) list three examples of underlying factors contributing to fatigue, work load and alienation aboard short sea cargo vessels sailing along the coast of Norway: a) "the administrative burden", 2) "de-skilling of the crew" and 3) "sleeping rules".

As we attribute our results on safety compromising fatigue to demanding working conditions, it is surprising that neither manning level, nor the number of port calls per week contributed significantly to safety compromising fatigue. These variables intuitively seem to be important for working conditions and job demands. Bivariate analyses indicate, however, that seafarers on vessels with lower manning levels (e.g. 3–4 people) seem to get less sleep and rest on board, experience more often demanding working conditions, and report of higher levels of safety-compromising fatigue. These results were, however, not statistically significant.

Finally, we found that having a good organizational safety culture decreases the risk of safety-compromising fatigue. Organisational safety culture was measured using an index consisting of 18 questions from the GAIN-scale on safety culture (cf GAIN 2001). The GAIN-scale originally consists of 25 questions measuring five themes: 1) Ship management commitment to safety, 2) Employee commitment to safety, 3) Reporting culture, 4) Safety training, and 5) General safety questions. The scale was reduced to 18 questions to facilitate the inclusion of other questions, measuring other topics. It is difficult to explain why a good organizational safety culture de-creases the risk of safety-compromising fatigue, but based on our analyses, we may hypothesise that having a good safety culture could make crew members better equipped to deal with demanding working conditions, which we have found crucial to safety-compromising fatigue. The importance of safety culture for dealing with fatigue has, as far as we have seen not been highlighted much in previous research. Future research should aim to clarify causal relationships further, i.e. whether the association we observe actually is due to the fact that vessels with less demanding working conditions develop more positive safety cultures, or whether actually is possible to reduce the impact of demanding working conditions by developing safety culture.

5 CONCLUSION

The study indicates that respondents' opportunities to get sufficient sleep and rest on board, and demanding working conditions influence safety-compromising fatigue. Deck personnel were more likely to be fatigued in manners that may compromise safety. The study also indicates that having a good organisational safety culture decreases the risk of safety-compromising fatigue. Thus, future research should examine whether safety culture interventions could be developed to counter challenging working conditions and fatigue. The study focuses on the coastal cargo sector, and previous research and qualitative data suggest a high work load and thus more fatigue in this sector.

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Reducing risk amongst those driving during work

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ABSTRACT: In-Vehicle Data Recorders (IVDR) are a tool which allows the monitoring, recording and reporting of driving behaviour. A number of studies have reported that IVDRs reduce risky driving and collisions, but these studies have substantial methodological short comings. Furthermore, a recent Randomised Controlled Trial (RCT) found no significant reduction in risky driving behaviour following the installation of the IVDRs and their associated interventions (in-vehicle warning devices and weekly feedback). A lack of knowledge regarding how to appropriately formulate and deliver feedback was identified as one of the shortcomings of that research. Therefore, the present study used a RCT to investigate whether feedback formulated and delivered using insights from behavioural science would lead to a reduction in risky driving behaviour. The research revealed that the treatment led to a statistically significant reduction in risky driving behaviour and a significant increase in seatbelt use.

1 INTRODUCTION

In the UK, motor vehicle collisions during work account for more occupational fatalities and serious injuries than all other causes combined (HSE, 2015, TUC, 2015). Similarly, it has been estimated that 60% of those killed on European Union roads each year were driving due to work (European Traffic Safety Council, 2015). With this in mind, it is surprising to note that there is a lack of rigorous scientific evidence concerning interventions that reduce work-related road risk (Grayson & Helman, 2011, Helman et al. 2014). However, one intervention which has shown some promise is the use of in-vehicle data recorders (IVDRs). IVDR's monitor and record different aspects of driving behaviour, providing a tool which can be used to contribute to the safety of those driving during work (e.g. Helman et al. 2014). However, telematics devices are basically only monitoring tools and thus it should not be surprising that there is currently very limited scientific evidence that using IVDRs leads to an improvement in work-related driver safety. Furthermore, the peer-reviewed research that does exist has substantial methodological short comings, such as: no control group, very short and strongly fluctuating baselines, relying solely on volunteers, and non-random selection (e.g. Hickman & Hanowski, 2001, Musicant, Lotan, & Toledo, 2007, Newman, Lewis & Warmerdam, 2014, Toledo & Lotan, 2006, Toledo et al. 2008, Wouters & Bos, 2000).

For example, in a study involving two transport companies, safety-related events were recorded over a four week baseline period and a 13 week intervention period (Hickman & Hanowski, 2011). Whenever a g-sensor alert was triggered during a drive, 12 seconds of video footage was recorded (8 seconds before the event and 4 seconds after) and saved for later review. Those incidents judged to be valid safety-related events were passed on to the appropriate company safety manager for review, and in some cases the manager reviewed the event with the driver and provided coaching. The researchers observed a 37% reduction in safety related events, from baseline to treatment period, in one transport company (Company A) and a 52.2% reduction in the other (Company B). However, this study has a number of methodological short comings that debase the evidence provided. For example, there was no control group, which means that any number of external factors may have been responsible for the observed reduction. Furthermore, while we would expect some degree of variation in the number of safety events recorded each week, the baseline measures for Company B ranged from around 1/10,000 miles to just over 8/10,000 miles. This degree of variability during a four week baseline period makes interpreting the findings very difficult. Furthermore, all participants included in the study were volunteers and were thus more likely to be interested in improving their driving safety than the general population. Finally, in Company A, 80% of the drivers with recorded safety events received coaching based around the safety event, while this process only occurred in 7% of the safety events in Company B. As the reduction in safety events was much larger in Company B it is even more difficult to attribute the observed reduction in safety-related events to the intervention, rather than this finding being as a result of the Hawthorne effect (individuals changing their behaviour simply due to being observed).

In a second evaluation of a commercially available IVDR, which utilised in-vehicle warnings and provided drivers with access to a website in order to obtain feedback about their driving (Toledo et al. 2008), the crash rate before installation of the devices was compared to a seven month period after installation. This showed a 38% reduction in collisions, but somewhat surprisingly there was no significant reduction in "at fault" crashes. These types of systems decrease crash risk by reducing driver engagement in risk taking behaviours and so we would expect the number of "at fault" collisions to be more greatly reduced than those where the drivers' were not at fault. In addition, although the number of participants taking part in the research was relatively large (n = 191), it was not clear how these individuals were chosen and random selection does not appear to have been used. However, most importantly this research did not include an appropriate control group. Crash involvement of those receiving the treatment was compared with those in the rest of the company, which cannot be considered to be an appropriate control group, as they were not monitored using the IVDR and presumably had less (if any) contact with the researchers. Therefore, the researchers were comparing one monitored group with an unmonitored group, meaning that any observed changes could simply be due to the Hawthorne effect. Further complicating matters, the authors reported a 19% company-wide reduction in collisions, indicating that other factors were improving safety within the company. Therefore, while the 38% reduction in collisions for the treatment group was larger than the 19% company-wide reduction, this could simply be due to inter-group differences. For example, those in the intervention group may have been more interested in improving the safety of their driving than those in the control group.

Research by Wouters and Bos (2000) investigated the impact of IVDRs on five different types of vehicle drivers (heavy trucks, trucks, taxi, coach and company cars). This study used a quasi-experimental design where the experimental group was compared with a "matched" control group and found an average 20% reduction in accidents. However, again the control group did not have IVDRs installed in their vehicles and presumably had limited, if any, contact with the experimenters. Furthermore, as group allocation was not random, selection bias could also have influenced the findings. This study also included two different types of driving recorders. The first type, Accident Data Recorders (ADR), only collect data just before and just after an accident has occurred. In contrast, Journey Data Recorders collect data on each journey (e.g. speed, acceleration, braking). There was also some variation in the method of feedback to the drivers, but clearly the drivers with the ADR could only receive feedback in the advent of a crash. This means that, aside from the drivers knowing they were being observed, the main effect of these types of systems would be on those who had at least one collision. Moreover, as the authors note, the group of drivers which accounted for more than 50% of the overall result (i.e. heavy truck drivers), only used ADRs, meaning that aside from the Hawthorne effect, the attempt to change driving behaviour (i.e. feedback) was only delivered following a collision. Furthermore, the difference between the control and treatment group was only statistically significant due to an increase in risk from the internal control group, rather than a reduction in risk for the treatment group.

Finally, a recently conducted randomised controlled trial was undertaken in Russia using 50 sales representatives. The randomly selected sales representatives were randomly allocated to four groups, which consisted of three treatment groups (weekly feedback and in-vehicle warnings, weekly feedback only, in-vehicle warnings only) and a control group. An eight week baseline period was followed by an eight week intervention period. The weekly feedback was delivered by the technology provider and in-vehicle warnings by a device professionally installed on the dashboard of the vehicle, which included flashing lights, icons and sounds to alert the driver whenever they engaged in the measured risky driving behaviours. This study found no statistically significant reduction in risky driving behaviour from baseline to treatment. In this case the interventions failed to encourage the drivers to change their driving behaviour (Sullman, 2014), which may be rectified by modifying the feedback delivered to the drivers using insights drawn from behavioural science.

1.1 *Aims and objectives*

As IVDRs are simply monitoring tools, the key to improving driving behaviour is in how the information is used. Therefore, the current study used a randomised controlled trial (RCT) to investigate the safety benefits of a commercially available IVDR when the feedback is modified and delivered to the drivers using insights drawn from behavioural science.

2 METHOD

2.1 *In-vehicle data recorder*

This study used a commercially available IVDR, which was provided, installed and serviced by the same company. The IVDR monitored the following types of driving behaviours:

1. Harsh braking
2. Harsh acceleration
3. Harsh left turns
4. Harsh right turns
6. Speeding (1–20 km above the speed limit)
7. Speeding (21 km + above the speed limit)
8. Seatbelt use

Whenever the driver exceeded predetermined limits (e.g. a limit for harsh acceleration) an alert was recorded and time stamped. As several of the alerts were infrequently triggered (e.g. harsh right turns), and to reduce statistical issues (e.g. inflating Type 1 error), it was decided in advance to only test for changes in the total number of alerts generated per 100 kilometres for behaviours 1–7 and that seat belt use would be examined separately.

2.2 *Procedure*

Information about the trial of the IVDR was circulated among all employees in the participating company. A total of 50 vehicles were selected to take part in the project, along with the drivers of these vehicles. Each vehicle was driven by a single employee and all employees were sales representatives for a large pharmaceutical company. The vehicles and drivers were randomly selected from the company's vehicle fleet (approximately 1500) which was spread throughout Russia.

The drivers of the vehicles selected to take part in the project received additional information about the project, including what the project was investigating, why they were investigating this and what taking part in the project would involve.

Following installation of the devices in the drivers' vehicles, baseline measures were made over a 17 week period. The drivers were then randomly allocated to one of three different groups, which are briefly summarised below:

- Group 1 – In-vehicle alerts and weekly feedback
- Group 2 – Weekly feedback only
- Group 3 – Control group

All three groups had a baseline period of seventeen weeks, during which time all alerts were logged, but the drivers received no notifications or feedback about their driving.

Following the seventeen week baseline period, those in Group 1 began receiving in-vehicle warnings whenever their driving generated a recordable alert. Group 1 also received weekly feedback via an emailed report. In contrast, Group 2 received weekly feedback (emailed report), but not the in-vehicle warnings. Group 3 was the control group and these drivers were simply monitored throughout the trial.

The feedback delivered to the drivers contained information about their driving behaviour during the previous week and compared their individual performance with the company aims of reducing risky driving behaviour and increasing seatbelt use.

2.3 *Ethics*

The study received ethical clearance from the Cranfield University ethics committee. All drivers were provided with adequate information about the study. They were also informed of their right not to participate and to withdraw from the study at any time without providing a reason and without penality. Participants were also told that the data collected during the project was completely confidential and that only the independent researcher and company providing the IVDR would have access to the data. Finally they were also assured that only aggregated data would be reported and that their individual data would not be identified in anyway.

3 RESULTS

3.1 *Alerts per 100 km*

The present article reports the results across the eight and a half months of the project. More specifically, this article compares the results of the 17 weeks of treatment data with the 17 weeks of baseline. The individual alerts/100 kms were collected weekly for each driver in each group, as well as their seatbelt use. Although there were 50 drivers at the beginning of the project, due to staff turnover, at the end of the experimental period there were 14 drivers in Group 1, 15 in Group 2 and 17 in Group 3 (46 drivers).

Figure 1 shows the mean number of alerts/100 km by week for the three groups across the 17 week baseline and the 17 week treatment period. This shows that both groups 2 & 3 appeared to be showing a slight increase in the number of alerts/100 km across the baseline period, while there was no clear pattern for Group 1 across the

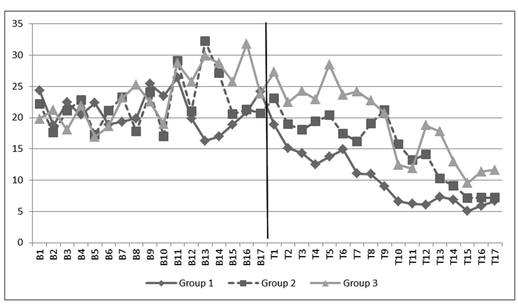

Figure 1. Mean number of alerts/100 km by condition.

baseline period. However, during the treatment period there were clear declines in the number of alerts/100 km for both groups 1 and 2. While the declines were obvious in both experimental groups, the decline was larger for Group 1 than for Group 2. In contrast, Group 3 (control group) showed no clear change up to week 9 (treatment period), but then a relatively clear decline was observed which mirrored the two treatment groups, but was not as pronounced or consistent.

The mean number of alerts for the three groups were then analysed for statistically significant differences between the baseline and treatment periods (Table 1). This shows that the means for groups 1 and 2 were significantly lower in the treatment periods than during the baseline periods (both $p < 0.000$). In contrast, for Group 3, there was no significant difference ($p = .185$) in the mean number of alerts by condition (i.e. from baseline to treatment period).

3.2 *Seatbelt use*

Figure 2 presents the percentage of seatbelt use by week for the three groups. This shows that during the baseline period groups 1 and 2 demonstrated relatively stable levels of seatbelt use (Group 1 around 90% and Group 2 around 77%). Group 3 broadly appeared to decline across the baseline period, moving from an average of around 86% at the start of the baseline period to around 77% at the end. However, during the treatment period the two experimental groups showed a relatively clear increase in seatbelt use, with the average for Group 1 being very close 100% for the last 11 weeks of the treatment period. Group 2 increased from an average of around 77% to be around 90% for the last 10 weeks of the treatment period. Interestingly seatbelt use in Group 3 was broadly flat for the first eight weeks of the treatment period but then increased from around 75% to above 85% during this period. However, it should be noted that this level of seatbelt use for Group 3 was to the same level recorded during the first few weeks of the baseline period.

Table 2 presents the overall means for the baseline and treatment periods for the three groups. This shows that the percentage of seatbelt use increased from 90.36% to 96.69% for Group 1 (baseline to treatment), which was statistically significant ($p < .001$). For Group 2 the increase in seatbelt use from baseline (76.87%) to treatment period (85.71%) was also statistically significant ($p < 0.001$). In contrast, Group 3 showed a statistically significant ($p < 0.05$) decrease in seatbelt use from baseline (83.15%) to treatment (79.92%).

Table 1. Mean number of alerts/100 km by condition.

		N	Mean	F	Sig
Group 1	Baseline	17	21.14	66.479	0.000
	Treatment	17	10.66		
Group 2	Baseline	17	22.16	18.839	0.000
	Treatment	17	15.34		
Group 3	Baseline	17	23.60	1.832	0.185
	Treatment	17	21.22		

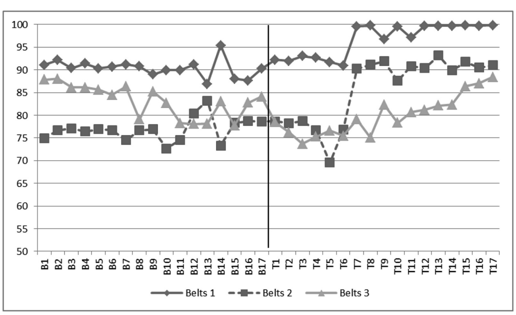

Figure 2. Mean seatbelt use by condition.

Table 2. Percentage of seatbelt use by condition.

		N	Mean	F	Sig
Group 1	Baseline	17	90.36	40.258	0.000
	Treatment	17	96.69		
Group 2	Baseline	17	76.87	21.616	0.000
	Treatment	17	85.71		
Group 3	Baseline	17	83.15	5.420	0.026
	Treatment	17	79.92		

4 DISCUSSION

Using data collected from In-Vehicle Data Recorders (IVDRs), the present study aimed to investigate whether feedback composed and delivered using insights from behavioural science would be successful in reducing risky driving behaviour. In contrast to the previous randomised controlled trial (Sullman, 2014), the present study found a significant reduction in risky driving behaviour and a significant increase in seatbelt use in the two treatment groups. The main difference between the previous study and the present study was that the feedback in the previous study was delivered by an individual without any formal training or knowledge of behavioural science, while in the present study the feedback was composed and delivered by a psychologist. Therefore, it appears that the success of this type of intervention depends a lot upon how the feedback is constructed and delivered.

Superficially, the positive finding made in the present study appears to support the previous findings of research on IVDRs (e.g. Hickman & Hanowski, 2001, Musicant, Lotan, & Toledo, 2007, Newman, Lewis & Warmerdam, 2014, Toledo & Lotan, 2006, Toledo et al. 2008, Wouters & Bos, 2000). However, in contrast to previous research, this study used a robust experimental design in order to reduce the number of alternative explanations for the findings. The absence of appropriate control groups in the previous research and failure to use randomised group allocation make any conclusions about their results difficult to justify, particularly with regards to excluding the Hawthorne effect. Unfortunately a lack of scientific rigour and the use of inadequate experimental designs is a common feature of interventions aimed at reducing work-related road risk.

The present study also showed that the use of in-vehicle warnings (Group 1) appeared to lead to larger reductions in risky driving behaviour, than were observed with weekly feedback alone (Group 2). Drivers in Group 1 instantly received in-vehicle warnings whenever they undertook risky driving behaviours (e.g. harsh braking), while those in Group 2 only received feedback about their driving behaviour on a weekly basis. This finding appears to support one of the principles of behavioural science, that being feedback is more effective when delivered close in time to the actual behaviour.

Previous research has demonstrated that appropriately composed and delivered feedback can be used to increase seatbelt use using both technology-based solutions (e.g. Sullman, 1998) and non-technology based approaches (e.g. Gras et al. 2003). The present study has demonstrated that a combination of both technological and non-technological approaches can be used to increase engagement in protective behaviours. In contrast to reducing risky behaviours, protective behaviours require the individual to engage in particular behaviours, in this case seatbelt use, in order to reduce risk of injury or death. The baseline averages found here ranged from 90.36% to 76.87%, which were already relatively high by Russian standards. These are considerably higher than the 56% reported in previous research in one region of Russia (Ma et al. 2012). This difference may be due to a number of reasons, such as the date of data collection or regional differences, but it may also indicate that this group of sales representatives was different from the general population of those driving during work in Russia in some important manner. For example, due to the nature of their job it is likely that they have a higher socio-economic status and they are also likely to be more highly educated than the general population of those driving during work in Russia.

The present research also found that seatbelt use in groups 1 and 2 increased from 90.36% to 96.69% and 76.87% to 85.71%, respectively, from baseline to treatment. These increases are particularly impressive, as increasing seatbelt use from an already high baseline is very challenging. However, although the actual rate of seatbelt use was higher in Group 1, both before and during the treatment, the absolute improvement in seatbelt use, from baseline to treatment, was larger for Group 2 (8.84%) than for Group 1 (6.33%). This finding does not conflict with the aforementioned principle, but rather demonstrates that it is easier to make larger absolute improvements in behaviour when the baseline is lower.

Although there are a number of ways in which data from IVDRs can be used, the present study included the two main approaches to improving driver behaviour using this technology, which are in-vehicle warning devices and the provision of feedback. However, there are a number of other approaches, such as using the information as the basis for rewarding or disciplining drivers, or to identify those in need of remedial training. It is likely that there are a number of different approaches that will lead to an improvement in driving behaviour, but as yet the scientific evidence is largely absent.

4.1 *Limitations*

The present study has a number of limitations. Firstly, the original sample was relatively small, with only 50 drivers being included in the study. This was primarily due to the costs associated with purchasing and installing the devices, as well as the time required to prepare and deliver the weekly feedback to the drivers. Furthermore, at the end of the 34 week period there were only 46 drivers included in the study. The four drivers lost were due to staff turnover (three drivers) and one sales representative who was promoted into another role within the company. Unfortunately these types of issues occur in field research and are beyond the control of the researcher.

It is likely that the characteristics of the present sample are not representative of the general population of those driving during work in Russia. Although personal details were not collected from the drivers (e.g. age and sex) in this study, the employees of the company working within this role were predominantly female (around 80%) and relatively young. However, according to the company in which this research took place, these worker characteristics are representative of their long term workforce in this role and are not some random short term fluctuation. Therefore, future research is needed to examine whether these improvements in driving behaviour can be maintained over a longer period of time and in different: organisations, industries, vehicle types and countries.

4.2 *Conclusions*

Previous research has demonstrated a lack of support for interventions based upon the use of IVDRs. However, the present research has shown that when feedback is delivered by those with an understanding of behavioural science IVDRs can result in a statistically significant reduction in the number of risky driving behaviours recorded. Furthermore, this research also demonstrated that this combination can also be used to increase engagement in protective behaviours (i.e. seatbelt use). In conclusion, although technology offers new and innovative methods for collecting and dealing with data, this approach is less likely to work if the human part of the system is not adequately taken into account.

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Risk management and safety culture: Case studies, best practices and further needs

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Mandatory OHS management is mostly an ineffective 'side-car' because employers delegate it away to un-empowered line managers

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ABSTRACT: It is essential to evaluate how mandatory OHS management is implemented, as it is the main strategy for work-health in the EU and many other countries. This was done in a large review of Systematic Work Environment Management (SWEM) in Sweden (transposing EU's Directive 89/391/EC). It used 267, mainly qualitative, studies to evaluate how SWEM is implemented at its three levels of management control. Medium and large employers nearly always delegated SWEM down to line managers with insufficient competence, time, resources and authority. These could only handle SWEM as a 'side-car' to the general management. Nor did top-managers audit and improve SWEM (as is mandated in the provisions). Nevertheless, line-managers' more systematic SWEM-procedures did resolve more technical risks, but organisational ones (e.g. stress and shift-work) were rarely systematically handled. Small firms and other more dependent employers (e.g. in supply-chains) had mostly only started to implement the 20 years old SWEM-provisions. Several international comparative studies indicate that Sweden's overall SWEM-results—more focus on documented procedures than on effective prevention—are valid also in other countries, at least within the EU.

1 HOW TO EVALUATE MANDATORY OHSM?

1.1 *OHSM is the strategy for work health*

To be effective, voluntary or mandatory systematic Occupational Health and Safety Management (OHSM) has to recognize reality: That occupational disease risks cause some nine tenths, while the one tenth of accidents is only the tip of the iceberg of all work-related ill-health. ILO has repeatedly described this overwhelming domination of long term occupational risks and estimated over 2 million fatal diseases and 320 000 fatal accidents world-wide in 2008 (ILO, 2011). In Sweden, a large epidemiological review (Järvholm et al., 2010) found well over a thousand occupational disease fatalities, while fatal accidents are less than fifty per year (AV, 2017).

Voluntary OHSM systems and regulated systematic OHSM are, since around 1990, the primary strategy to reduce these widespread OHS risks (Frick et al., 2000a). This paper focuses on the mandatory OHSM (which differs from the e.g. much more complex voluntary OHSM systems; Frick, 2011a). It presents Swedish employers' comply SWEM's requirements, but also argues that these results are generalizable to other countries.

Most OECD-countries have regulated how employers are to organise systematic and proactive prevention of work risks. The US is an exception, but its largest state, California, has mandatory safety and health programs since 1991 (Sheridan, 1991). The most important example is EU's Framework Directive (FD; 89/391/EC), which governs the OHS regulation in all 28 member countries. The FD introduces the broad concept of the 'working environment'—to explicitly cover also organisational risks—and mandates how employers are to organise an upstream prevention.

1.2 *OHSM as a success, paper-tiger or sham?*

Mandatory OHSM has been described as a shift from the old prescriptive standards (telling employers what to do), over performance standards (mandating OHS-outcomes, such as HTV or safety against falls, but not the means to achieve them) to OHSM as process standards (on how employers are to manage OHS in order to achieve an effective prevention (Gunningham & Johnstone, 1999). However, the effectiveness of 'making employers do the job' by regulating their OHSM-process has been debated. Frick et al. (2000b) summarized this as three alternative hypothesises of the OHS-outcomes:

- The *success hypothesis* focuses on the aim of OHSM. Although earlier regulations in many countries aimed to strengthen standards, enforcement and workers participation, in practice local management still gave OHS a low priority. The result was that OHS activities were often sloppy and the issue remained marginal to the organization. Therefore emphasis has to be given to improve top-management commitment to OHS management. While all realise the huge problems to assure universal compliance with OHSM regulations, some still see them as major instruments to raise the general efficiency in detecting, abating and preventing work hazards.

- The *paper tiger hypothesis* doubts that the high aims of the OHSM strategy can be realised. The strategy is limited to the relation between employers and their workers, while more and more of the OHS conditions are caused by other factors. Even within the employment relationship, the means of the OHSM strategy—also in their simpler, regulated forms—may be inappropriate and hard to implement. The focus on the (documentation of the) process of management is based on a mechanistic model of organisational processes, which may obstruct traditional, and partly effective, shop-floor strategies for dealing with OHS. From this position OHSM is at best largely a waste of effort, taking up scarce resources that could have been better used through traditional OHS strategies. At worst, OHSM becomes a strategy for giving management power at the expense of the workers.
- The *sham hypothesis* is openly critical of the value of OHSM. It sees it largely as a pretext to deregulate the field of OHS. A paper obligation to manage OHS may easily become a justification for fewer substantive regulations, or for vague and less easily enforced standards that effectively shift OHS further within the orbit of employers' discretion. The emphasis on the employer's duty to manage OHSM may also be used to reduce the influence of workers and to increase management's control of their work".

1.3 *Two recent major OHSM-evaluations—of EU's framework directive and Sweden's SWEM*

How these alternatives outcomes are combined in practice is hugely important. In essence, how EU-employers implement the FD's proactive quality control of the work environment determines the work related health of the union's workforce. And this occurs in a demographic situation where a prolonged work ability and later retirement is crucial to maintain the economic basis for our welfare societies (European Commission, 2012; SOU 2013: 25).

Two major evaluations of the effectiveness of mandatory OHSM have recently been published. Employers' compliance with FD (and its daughter directives) in the EU and in each of its member states was studied, as part of EU's REFIT-programme (COWI et al., 2015; European Commission, 2017). This was proceeded by an evaluation of how Swedish employers, overall and per industry, comply with the provisions on Systematic Work Environment Management (SWEM, AFS, 2001; Frick & Johanson, 2013; Frick, 2013a; English summary in Frick, 2014). SWEM transposes the FD-requirements, with strong rights for workers, and especially their safety representatives, to participate in the employers' SWEM (Sjöström & Frick, 2017). Unlike the FD, the SWEM-provisions also require employers to audit and (if needed) improve the effectiveness of the conducted SWEM to detect, prevent and abate risks (see further below).

1.4 *Qualitative studies only alternative as quantitative manager surveys are white-washing*

The EU-evaluation was largely based on a quantitative survey (ESENER 2; EU-OSHA, 2016) to managers of their OHSM. The Swedish one is instead a meta-review of all qualitative studies on how the work environment is managed at various types of workplaces. This methodology was chosen for several reasons (Frick & Johanson, 2013, p. 34–37; Frick, 2013a, p. 7–10).

The major one was that management surveys have serious flaws in their reliability and validity. With mostly very low response rates (ESENER's is on the average around 20 per cent) the answers have a very low statistical accuracy. OHSM-surveys are also limited to a minority of employers as micro-firms—which make up some 85–90 of all—are hard to reach. The answers also have a poor validity. The surveys only ask for some OHSM-procedures (notably having a document labelled 'risk assessment'), not how these means prevent risks (while both the FD and SWEM are defined as 'managing operation without OHS risks'). Finally, the answers are given by managers who want to show a good compliance but mostly have a limited knowledge of what this requires. An example of the 'white-washing' of such survey-answers, was the claim in the EU-evaluation (European Commission, 2017, p. 20) that on the average some 70 per cent of the union's employers regularly assesses risks at work. However, some 95 per cent of these are small and micro firms and there is an overwhelming evidence that these firms have a poor OHSM, including ignorance of risks and regulations and serious over-estimation of their risk-knowledge (Frick, 2013a, ch. 10).

Another reason to use case-studies in the Swedish evaluation is the existence of much untapped and accessible such qualitative knowledge. The data-base search found some 700 studies on various aspects of OHSM-practices. Some were peer-reviewed research but most were 'grey literature' of more practical reports and student exam papers. After a quality assessment of their methodology and relevance, 267 studies were selected for the SWEM-evaluation. Most were single or multiple case studies but there were also studies of (aspects of) OHSM covering a few industries, a couple of more delimited research reviews, around twenty labour inspection reports on compliance in various industries, and some union surveys to their workplace safety representatives (Frick, 2013a, p. 7–10).

As would be expected, there were variations in SWEM, both between industries and between more or less compliant employers within them (Frick, 2013a, ch. 2–11). However, there was nevertheless a very large consistency in the studies' reported strengths and weakness in the employers' SWEM, both overall and at each SWEM-level (see below). The pattern of more procedural compliance than integrated prevention was repeated again and again in the cases. Another sample of 250 cases (out of some 300 000 employers) would therefore hardly come to much different results. The description of the various levels of SWEM-compliance was further supported by quantitative data on risks and health at work from reasonably reliable and valid (Wikman, 1991) employee surveys (AV, 2016a; AV, 2016b).

1.5 *A change model of OHSM-implementation*

A qualitative methodology was also choosen as only this can describe OHSM as a change process, while survey data can (at best) reveal what is done but not why. Based on the structure of the SWEM-provisions and on a review of research on management control, Frick & Johanson (2013, ch. 1 & 4) structured and evaluated the implementation of SWEM as three levels of management control. This was used as the programme theory in a realistic evaluation (Pawson, 2006) of SWEM:

I. What to do?: Procedures to detect and abate risks; Organised routines; Risks assessments (RA); and Action plans (AP).
II. How to do it? Empower actors through: Integrate into daily management; Allocate tasks; Participation by employees and their safety reps; Time, funding, competence and authority to all with SWEM-tasks; and Engage OHS-services when managers' own competence is insufficient,
III. Management control that SWEM is effective: SWEM is defined as risk-prevention (the procedures are thus only means); Policy with work environment objectives; Yearly auditing and (if needed) improvement of SWEM.

Control level III—auditing and improvement—constitutes the secondary learning loop in quality control, the was considered essential in the ILO-review of the effectiveness of OHSM (Dalrymple et al., 1998). The logic in this quality control is that if there is a (lasting) risk, this is caused by a fault in SWEM (in practice, in how line managers detect, prevent or abate risks). And if there is a deficiency in the line-managers' SWEM practice, this in turn signs a deficiency in the employers' compliance with the mandatory quality control of auditing and improving SWEM.

However, most mandatory OHSM—the FD included—lacks this requirement of a tertiary level of management control, through auditing and improvement, which is required in SWEM (and in the similar Norwegian provisions on Internal Control; Gaupset, 2000). The FD mandates employers to prevent OHS risks, which thus defines compliance not only as having risk assessments and other documented procedures but by their results in the work environment. However, the FD does not go into how employers are to comply, through a learning and development process (requiring auditing and improvements). It simply orders them to implement all necessary precautions (including as further specified in the Directive, and in its national transposing regulations).

2 SOME SUCCESS IN SWEM'S TECHNICAL PREVENTION BUT MAINLY A PAPER-TIGER AGAINST ORGANISATIONAL RISKS

2.1 *Main focus on procedures, less on SWEM-empowerment and least on effective prevention*

The evaluation's overall result was that some 20 years after SWEM became mandatory (albeit 1993–2000 labelled Internal Control; Frick, 2002), the large majority of employers still struggle to understand and comply with its requirements. It is especially uncommon to integrate its prevention strategies into top-management. Medium and large employers are a very small share of all but they have some two thirds of all Swedish employees. There are variations in their compliance, i.e. in the prevention, both between industries and between 'better' and 'worse' employers within them. Yet, the case-studies demonstrate that nearly all of these professional employers with structured organisation, including task distributions and HR-specialists, have many documented SWEM-procedures, such as regular meetings and written risk assessments (RAs) and action plans (APs) of improvement. However, not all risks are assessed (especially not organisational ones) and APs are not always implemented, which results in many unresolved risks.

A typical case (of a 'better' employer) was a paper mill in which SWEM was (as nearly always) mainly delegated down to the line managers. These felt reasonably able to manage technical risks (for e g. accidents or chemical hazards), on which they had some training, but lacked both competence and support to handle the (considerable) organisational health risks of stress and shift-work. Top-managers only followed up the line-managers formal SWEM (with meetings and safety rounds) but not how these procedures resolved risks.

The limited effectiveness of line-managers procedures at SWEM's level I is caused by top-managers' insufficient empowerment of them as SWEM-actors at level II (see further Frick, 2013a, ch. 2–11, on the SWEM-practices in various industries):

- The task allocation was only superficially clear. Line managers mostly sign documents of delegated OHS duties, but these delegations rarely comply with the provisions' strict requirements, intended to assure that those with SWEM-tasks are capable of executing them. And the combined right and duty to, if necessary, return SWEM-tasks to higher levels with more authority and resources, is mainly theoretical. This is normally interpreted as a failure as line-manager (again, without a top-management audit if OHS-risks are resolved or not).
- Those with allocated SWM-tasks get too little time, competence, funding and authority to execute these well. Line manager's main complaint is 'lack of time' for their SWEM-duties. However, in practice this means that top managers have not prioritzed these preventive activities. Despite the provisions duty for employers to inform and train all with SWEM-tasks, lack of competence was also very common, both as line-managers' unrecognized overestimations of their common-sense OHS-knowledge and as their acknowledged need for more competence on organisational and social health risks
- Swedish some 4.5 million employees have, through their trade unions, elected around 90 000 safety representatives (equaling some 7,500 full-time positions; Sjöström & Frick, 2017). Safety reps have strong rights for e.g. time for their taks and information from and a dialogue with managers, both in the Work Environment Act (chapter 6) and in SWEM. However, in practice, safety reps go to many meetings, but they are still very often not involved in the planning and managment of production that determines the health risks (Sjöström & Frick, 2017).
- OHS-services are rarely hired to support an effective prevention. Rather, only those employers with the highest ambitions—and mostly with the best internal competence—hire OHS services much to support a further improvement of their prevention. I.e., the more ignorance there is among managers (and this is widespread, in at least important respects of risks and prevention duties), the less preventive competence is hired from the OHS-services. These are instead mainly providers of individual health services and health promotion (see also Schmidt & Sjöström, 2015).

Employers' insufficient empowerment of their SWEM-actors is in turn caused by even poorer compliance at level III. Contrary to the provisions, SWEM is mainly interpreted as having documented risks assessments (but with mostly insufficient coverage and root-cause analysis), regular meetings and other procedures. When done at all, the yearly auditing of SWEM rarely checks anything more than if these documents exists, not how effective they are to reduce work-risks. This confusions of ends and means in nearly all SWEM-practices is aggravated by the normal use of sickness absence and reported worker compensation cases as the only risk indicators, despite that variations in both mainly depend on other factors than the work environment (Larson et al., 2005; Torén, 2010).

The reviewed studies report that the lack of full compliance with the SWEM-provisions results in many overlooked or unresolved risks. However, at the same time, these studies also indicate that the implementation of more systematic routines, and hence effective, SWEM-routines in the daily management of especially technical risks. These types of risks are more or less known, at least in organisations with some OHSM-traditions, and they are mostly clearly regulated. Hence lower manager can, if necessary, often get extra funding from above to resolve them. In all, SWEM against technical risks can therefore be decribed as the proverbial both half-empty and half-full glass. But organisational risks—notably of work related stress, of ergonomic risks due to the work organisation, of threats and violence, of bullying and of health risks from shift-work—are rarely effectively handled in the medium and large employers' SWEM, as this would require integration of OHS-considerations in the planning and management of production, a SWEM-requirement that only a few employers comply with.

2.2 *Variations within and between industries*

Manufacturing, with its old OHSM-traditions, was on the average the best industry in its effectiveness to implement SWEM. But the cases also described how manufacturing employers in reality—as shown by line-management practices—can be ranked at increasing levels of ambition: From many who focus only on accident prevention (i.e. the 'tip of the ice-berg), over others that also try to reduce most or many other technical risks (such as noise and other exposures), to the more ambitious that were fairly systematic in reducing ergonomic-musculoskeletal risks. However, only a few employers did in practice try to manage the (common) organisational risks for stress and-or from shift-work and bullying (Frick & Johanson, ibid, p. 38–43).

The pattern of SWEM-implementation is, as mentioned, the same in all case studies and other reports, also across industries. Private services—which is a large and very diverse sector—on the whole had a less effective SWEM than in manufacturing, but some of their larger employers (.e.g. in retail trade) still had high ambitions (though there were few data on its effects on actual risk prevention). The larger office-dominated private services, such as finances, nearly always had formal SWEM-procedures but these were mostly inefficient in handling stress that was their major health risk. In construction, the dominating few large companies tried to organise an effective SWEM and achieved some OHS-improvements. However, these were much hampered by the industry's price- and time-pressures and by its wide-spread subcontracting (often in several steps, with e.g. a Polish 'self-employed' carpenter at the bottom; Frick, 2013, ch. 2).

The some 300 large to very large public employers of local authorities/municipalities and regions are responsible for some 'technical' issues (e.g. public transport) but their predominant activities are welfare services, notably education, health care and care for the elderly. There are long traditions of a social dialogue and of e OHSM within this public sector. This has led to extensive SWEM-practices of training, meetings and documented procedures. are ineffective. Nearly all SWEM-practices are delegated down to individual local levels (e.g. schools or hospital wards). Yet, the extensive dialogue between principals, and other local managers, and the safety reps, does rarely reach the higher planning and management levels of these complex organisations at which decisions of tasks and resources are taken. And it is these decisions that determine the work-load, and hence the very extensive stress-risk (and also widespread ergonomic risks), in the schools, hospitals, elderly care and social agencies and other welfare workplaces. This poor communication between higher levels of planning and lower operative ones in the public sectors' SWEM, results in an unusually large gap between very much documentation and activity (at the workplaces' SWEM level I) but very inefficient employers management control OHS at SWEM level III. This sector was thereby a clear case of a 'paper-tiger' implementation of SWEM (Frick, 2013, ch. 5–6).

2.3 *Poor SWEM in small firms*

As in several countries (see e.g. Walters, 2001; and Hasle & Limborg, 2004), there is fairly much research on OHSM in small firms also in Sweden (Frick, 2013a, ch. 10). And like elsewhere, the Swedish studies reveal a mostly poor compliance with SWEM's three levels of management control. Some notable results are that:

- The SWEM-implementation is strongly linked to firm-size. Larger ones (20–49 employees) have very often started some implementation, including with some documented procedures, although these mostly are not very effective. Micro-firms, on the other hand, very often do not even know of the provisions.
- Owner-managers allocate much too little to to their SWEM-duties, and this is linked to a vicious circle of widespread ignorance of risks and prevention, overestimation of their own competence and their firms' OHS-quality, and low motivation and priority for systematic improvements.
- There is little support to improve the owner-managers' poor SWEM as small firms mostly do not hire OHS-services and when they do it is rarely to improve their prevention. The number of safety reps per employee is much lower in small firms, and the few and single reps have a weaker position than in larger workplaces. And the large cut-backs to the labour inspectorate has resulted in that they can only visit each small firm once in some twenty years.
- However, the Swedish system of union appointed regional safety reps (RSR; Frick, 2009) do provide some safety net for OHSM of both employees and employers in small firms. Even though this is a poorly resourced net with large meshes, the RSRs are to main actors to support better SWEM in small firms.

3 CONCLUSION: OHSM COMPLIANCE IS MAINLY A 'SIDE-CAR' ALSO IN OTHER COUNTRIES

With all these shortcomings, the case-studies and other reports used in the Swedish evaluation nevertheless indicated that the gradual increase of SWEM-practices improved a more systematic approach to prevent technical risks at work.

The improved technical prevention is a partial support for the success-hypothesis of regulated OHSM. However, there are also many cases of overlooked or unresolved technical risks, while the (widespread) organisational risks are more raised but still rarely effectively managed, This often also includes problems to handle how the organisation of production causes ergonomic risks.

There is thus also much support for the hypothesis that SWEM-practices are 'paper-tiger, with much more talks and documents then any effective prevention. However, after the SWEM-evaluation, the Swedish Work Environment Authority (SWEA) issued provisions on the Organisational and Social Work Environment (AFS, 2015; the 'OSA-provisions'). These provisions hardly contain any new requirements but rather collect existing ones from various provisions and present them in one comprehensive regulation on health risks from workload (i.e. mental, not ergonomic that are covered by separate provisions), working time (notably shift-work) and bullying. OSA, explicitly refer to the SWEM-provisions. SWEA presented OSA with very much information and the provisions have lead to very much training and debate on how to improve SWEM against organisational health risks at work. However, it is too early and there is no real evaluation of how this important but hitherto neglected aspect of SWEM has improved.

The general results of Sweden's SWEM-evaluation should be valid in other OECD-countries, especially in the EU. The FD mandates a proactive OHSM everywhere. The basis to implement the mandatory OHSM is also similar, through the same type of organisation, technology and management of production (differing by industries and sizes) of the same types of firms operating in and on the common market. If anything, the SWEM-practices compliance with the FD's requirement should be better than average as Sweden has relatively strong OHS-actors (Frick, 2014).

There are no other large national evaluations how the mandatory OHSM is implemented (while the ESENER-results, unfortunately, are not credible). However, several national and comparative studies on OHSM-practices still indicate the same formalistic patter of implementation as in Sweden. The first management control level of documented procedures is somewhat implemented by medium-large employers, while small ones have much less OHSM. However, the empowerment of OHSM-actors (level II) is less developed and employers' quality control that their OHSM is effective (level III) is mostly is poor (e.g. Jensen, 2002; Walters et al., 2002; Gallagher et al., 2003; Walters et al., 2011; Hasle et al., 2014).

The prevalence of serious risks to health (mainly) and safety (only the tip of the iceberg) at work is therefore—at least in the EU, and probably also elsewhere—primarily due to the employers and their top managers' lack of commitment, organisation, resourcing and control of how line managers can prevent and resolve health risks in the production. SWEM, and other OHSM regulations, are still poorly implemented. They nearly always remain as a 'side-car' that is poorly integrated in the overall management. As such, SWEM-/OHSM-duties are tasks delegated away to line managers, with little integration in the planning and management of the risks' root-causes in the organisation and technology of the production. And where there is any more OHS-dialogue between managers and employee safety representatives, this too does not reach these crucial higher levels of decision.

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Safety culture in a shipping company. Evidence from two surveys 13 years apart

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ABSTRACT: Two surveys 13 years apart (2002 and 2015) using identical questionnaires collected data on crew from a Norwegian ship owner. The survey used reliability tested scales and items from previous research measuring 12 different factors: 1) Satisfaction with safety activities, 2) Management control, 3) Fatalism, 4) Knowledge/competence, 5) Conflict between work and safety, 6) Reporting culture, 7) Communications, 8) Management attitude towards safety, 9) Positive management behaviour, 10) Job satisfaction, 11) Attitudes towards safety rules and 12) Learning culture were linked to *four different dependent behavioural scales (outcome variables) used in previous research:* 1) Positive management behaviour, 2) Precautionary behaviour, 3) Laissez-faire behaviour and 4) Laissez-faire behaviour under pressure. Significant positive changes between 2002 and 2015 appeared for factor 1, 2, 4, 5, 6, 7, 9, 10 and 12, a significant negative change were found for factor 3 and no significant change were found for factor 8 and 11.

1 INTRODUCTION

Culture is not an easy concept to define and by reviewing "the culture literature" hundreds of definitions appear. Already in 1952 a critical review of the concept and definition of culture—carried out by the American anthropologists, Kroeber and Kluckhohn—compiled a list of 164 different definitions. Anthropologists, psychologists, political scientists, and sociologists all differ in their definitions of culture along with the distinction between culture and climate, and the concept of both culture and safety culture has over time been a theme of heated discussion, with little theoretical consensus emerging on the ontological, epistemological, and methodological questions relating to the subject. The main differences in these questions seem to be: (1) What is the scope of safety culture and the relationship between culture and climate? (2) How does the concept relate to other organizational aspects and outcome? (3) Which methods are most suitable for measurement? (Oltedal. 2011). These fundamental questions have already been elaborated upon by many researchers and although we are well aware of the nature of the debate, this will not be a new contribution to the debate (Håvold, 2000; Guldenmund, 2000), however rather discuss how the concept has be used within the maritime industry.

Another discussion going on since the 1990s is how safety culture is linked to national culture, organizational culture and professional culture. This is debated in papers and books (for example Helmreich and Merritt, 1998; Reason, 1998). Helmreich and Merritt (1998) proposed that culture fashions a complex framework of national, organizational and professional attitudes and values within which groups and individuals function. Their research show a link between national cultures, organizational culture, stress and safety. In situations where national culture and organizational cultures are in harmony, stress factors do not influence safety, but situations where national culture and organizational culture values conflict might lead to stress and influencing safety. Many scholars, among them Reason (1998), Cooper (2000) and Guldenmund (2000) view safety culture as a subculture to organizational culture.

Within the myriad of cultural definitions that exist, one have do make a stand. Culture is bigger than any one discipline, and much can be learned from accepting all definitions simultaneously. Thus, in this chapter we intent do discuss further the most common cultural model, which breaks the concept down to the central building blocks basic assumptions, values, norms and artefacts. Below are antecedents to safety culture based on a review in 2002, which the scales used in 2002 are based on:

Satisfaction with safety activities. A comprehensive measure of safety activities at work, including training, housekeeping, controls, inspections and safety improvements. (Mearns et al., 2000)

Fatalism. This characteristic reflects an individual's belief in destiny, that all events have been predetermined and that there is not much that can be done about what happens. This is a social construction of risk perspective. Rundmo and Hale, 1999; Williamson et al., 1997).

Knowledge/Competence. Knowledge and training are in themselves insufficient for developing a safety culture or safety orientation; however, research suggests that safety knowledge is an important factor in predicting safety compliance. The factor includes knowledge and understanding of rules and regulations, of how to behave regarding the policies, routines, processes, laws and systems that affect safety. (Hofmann et al.,1995; Cooper, 1998; Mearns et al., 2000; Grote and Künzer, 2000; Håvold, 2001; Neal et al., 2000).

Conflict between work and safety. One of the main characteristics of a positive safety culture is that every individual member of an organisation accepts the responsibility to behave as safely as possible to avoid and prevent accidents. (Harvey et al. 2002; Cox and Cheyne, 2000; Lee and Harrison, 2000)

Reporting culture is about how prepared employees are to report their errors and near misses. Such a culture depends upon how organisations handle blame and punishment. This does not mean amnesty for all unsafe acts, because that will reduce credibility in the eyes of the workforce. (Reason, 1997; Mearns et al., 2000; Cox and Cheyne, 2000).

Communications refers to the degree of openness and extent to which communications reach all levels in the organisation. (Harvey et al. 2002; Mearns et al. 2000; Cox and Cheyne, 2000; Rundmo and Hale, 1999).

Managements attitudes to safety is a very important factor. Attitudes are an indicator of safety performance and includes management commitment and involvement in safety work, the degree of openness and extent to which communications reach all levels in the organisation. (Lee, 1998; Rundmo 1992; Rundmo and Hale, 1999; Harvey et al., 2002; Mearns et al., 2000; Grote and Künzer, 2000; Cox and Cheyne, 2000).

Job satisfaction. Employees who are more satisfied with their work believe that the organisation will be satisfying in the long run, care about the quality and safety of their work, are more committed to the organisation and are more productive. (Harvey et al., 2002, Glendon and Litherand, 2001; Grote and Künzer, 2000; Rundmo and Hale, 1999).

Learning culture. To become a learning organisation is to accept a set of attitudes, values and practices that support the process of continuous learning within the organisation. (Reason, 1997; Senge, 1990).

Safety rules refers to how practical and easy the rules are in terms of understanding and following without conflicting with work practices or when a job is rushed. (Harvey et al. 2002; Mearns et al., 2000; Cox and Cheyne, 2000).

Behaviour (OUTCOME VARIABLE). Behaviour seems to be well correlated with accident performance, and behaviour can be observed every time a job is performed. How organisations and members in organisations behave when it comes to work and safety does influence safety culture. On an individual level, a person's beliefs about a risky behaviour as well as his/hers attitude towards accident prevention does affect risk perception, behavioural intentions and behaviour. (Ajzen and Fishbein, 1980; Rundmo, 1998).

Laissez-faire refers to letting people do what they want. The questions are taken from work done by Mearns et al. (2000).

The aim of this study is to investigate if safety culture measures changes over time. Is it possible to find explanations to observed changes? Are the safety culture factors influencing behaviour in 2002 the same in 2015?

2 MATERIAL AND METHODS

2.1 *Organizational setting*

The fieldwork of this paper is performed in a tanker company located at the west coast of Norway. The size of the company when it came to numbers of employees were almost the same in 2002 and 2015.

2.2 *Reliability and validity*

Scales are reliable to the extent that they are comprised of reliable items that share the common latent variable. The most common way to measure reliability of a scale is to use Cronbach's alpha which is used in this paper.

The measures used in the questionnaires are derived from an exhaustive literature review and are evaluated by both practitioners and academics.

Although the judgements about *content validity* are subjective, the procedures used are consistent with ensuring content validity. *Construct validity* (Cronbach & Meehl, 1955) is directly concerned with the theoretical relationship of a variable (e.g. score on some scale) to other variables. It is the extent to which a measure "behaves" the way that the construct it purports to measure should behave with regard to established measures of other constructs (DeVillis, 1991; Spector, 1992). Despite some minor problems with both convergent and discriminant validity for a few of the concepts, the overall fit and the correlations between the constructs indicated congruent and concentric measurement models.

2.3 *Procedure*

The sampling technique were census sampling and the whole crew was invited to answer the questionnaire.

The participants voluntarily took part in the study, and information on project aims and confidentiality preceded the collection of data. To protect confidentiality, the names of vessels and ship-owners have not been reported, and results from a group level have only been reported for work groups exceeding 10 persons.

2.4 *Items and scales*

Items and scales of the different constructs used in the questionnaire are from previous scientific research, which is validated, and reliability tested. The 2015 questionnaire was designed to cover the same aspects as the 2002 questionnaire, making it possible to compare the results from the two surveys. The 2015 surveys had 48 items about safety culture and safety behaviour taken from the 2002 questionnaire. A 6-point Likert scale was used in both surveys: 1 strongly disagree, 2 disagree, 3 mildly disagree, 4 mildly agree, 5 agree, and 6 strongly agree. It is important to use identical scales because otherwise it would be difficult to compare results, however, some of the 2015 scales were shorter as a result of the 2002 study (Håvold and Nesset, 2009).

Table 1 shows the Cronbach's alpha coefficients of all constructs in 2002 and 2015 surveys. Most of the alpha coefficients are satisfactory and above 0.6 for both surveys (Cronbachs and Meehl, 1995).

In 2002, Håvold (2007) collected data from a shipping company and in 2015 Ashraf (2016) collected data from the same company replicating the study. The same demographic questions and most of the safety culture questions used in 2015 as 2002, however, some of the scales were shortened because of the result of the first study. Some of the reliability measures (alphas) were improved in the new study while others did not reach the level of the 2002 study. Cronbach's alpha coefficient for management control was 0.50 in the 2002 study and 0.44 in the 2015 study. Cronbach's alpha for knowledge competence was 0.85 in 2001 and we can see decrease in value to 0.75 in 2015. Cronbach's alpha coefficient for reporting culture was 0.83 in 2015 and 0.74 in 2002. Reliability coefficient for management attitude towards safety was 0.79 in 2015 and 0.64 in 2002. Cronbach's alpha coefficient for positive management behavior decreased from 0.78 in 2002 to 0.67 in 2015. Behavior yielded Cronbach's alpha 0.52 in 2015 and 0.35 in 2002. Laissezfiare under pressure measure yielded Cronbach's alpha 0.73 in 2002, which decreased to 0.65 in 2015.

Table 1. Cronbach's alpha of all constructs.

	Alpha	
Factors/ Source	2002	2015
Satisfaction with safety activities	0.87	0.85
Management control	0.50	0.44
Fatalism	0.83	0.84
Knowledge/competence	0.85	0.75
Conflict between work and safety	0.74	0.72
Reporting culture	0.74	0.83
Communication	0.64	0.61
Management attitude towards safety	0.69	0.79
Positive management behaviour	0.78	0.67
Job satisfaction	0.67	0.61
Behaviours	0.35	0.52
Attitude towards safety rules	0.77	0.78
Precautionary behaviour	0.57	0.59
Learning culture	0.81	0.80
Laissez-faire behavior	0.83	0.81
Laissez-faire under pressure	0.73	0.65

3 RESULTS AND DISCUSSION

The main focus in this paper is on the comparison of the findings of researches conducted in 2002 and 2015. In 2002, Håvold collected data for his PhD at this shipowner (Håvold, 2007). The same demographic questions were used in 2015 as 2001. Table 2 presents a comparison of demographic data from the samples in 2001 and 2015. The sample size was more than double in 2001 compared to the sample size of 2015. The ratio of females was 3.97% in 2001 whereas in 2015 female participants' ratio decreased to 1.03%. Majority belonged to the age group 26–35 in 2001. On the other hand, in 2015, the two age groups had a close proportion of sample population from 26–35 and 36–45. The number of nationalities in the sample increased from 5 to 12 nationalities.

Mean and SD for 12 different antecedents to safety: 1) Satisfaction with safety activities, 2) Management control, 3) Fatalism, 4) Knowledge/

Table 2. Demographic data 2002 and 2015.

	2002	2015
Sample size	408	197
Percent male	96	99
Percent female	4	1
Age percent		
18–25	18.6	6
26–35	30.3	31.5
36–45	23.5	33.5
45–55	21.8	20.3
Above 55	4.4	7.6
Nationalities	5	12

competence, 5) Conflict between work and safety, 6) Reporting culture, 7) Communications, 8) Management attitude towards safety, 9) Positive management behaviour, 10) Job satisfaction, 11) Attitudes towards safety rules and 12) Learning culture (see Table 3). The antecedents were tested on *four different dependent behavioural scales (outcome variables) and reliability tested and validated (for a more theoretical paper see Håvold and Nesset, 2009)*. The four behavioural scales was: 1) Positive management behaviour, 2) Precautionary behaviour, 3) Laissez-faire behaviour and 4) Laissez-faire behaviour under pressure can be seen in Table 3.

Significant positive changes between 2001 and 2014 appeared for factor 1, 2, 4, 5, 6, 7, 9, 10 and 12, a significant negative change were found for factor 3 and no significant change were found for factor 8 and 11 (t-tests).

Table 3. Mean and SD for all factors/antecedent.

Factor	Year	Mean	SD
1. Satisfaction with safety activities	2015	5,0	0,58
	2001	4,5	0,80
2. Management control	2015	4,8	0,66
	2001	3,4	0,66
3. Fatalism	2015	2,9	1,35
	2001	2,5	1,14
4. Knowledge competence	2015	5,1	0,45
	2001	4,9	0,71
5. Conflict between work and safety	2015	2,9	1,06
	2001	3,3	1,13
6. Reporting culture	2015	4,8	0,80
	2001	4,7	0,86
7. Communication	2015	4,8	0,56
	2001	4,7	0,79
8. Management attitude towards safety	2015	2,4	0,96
	2001	2,3	0,92
9. Positive management behavior	2015	4,8	0,65
	2001	4,5	0,91
10. Job satisfaction	2015	4,2	1,05
	2001	3,8	1,13
11. Attitude towards safety rules	2015	2.2	0,88
	2001	2.1	0,84
12. Learning culture	2015	5.0	0,76
	2001	4.5	0,91
1. Behaviours	2015	4.6	84
	2001	4.5	0,91
2. Precautionary behavior	2015	5.4	0,59
	2001	5.0	0,66
3. Laissez-faire behavior	2015	1,8	0,80
	2001	2,2	1,01
4. Laissezfiare under pressure	2015	2,1	0,82
	2001	1,9	0,81

4 CONCLUSION

By evaluating an organisation's safety culture through a survey instrument, it is possible to produce a picture of the vessel and/or ship owner at a particular point of time. This suggests that the instrument can be used to plan and implement change.

The measurement of safety culture can provide management in an industry like shipping with the capacity to measure the degree to which the underlying dimensions in safety culture influence behaviour. In the 2001 study (Håvold, 2009) it has been shown that the scale was internally reliable and provided a valid construct when tested on a sample of seafarers on Norwegian-owned vessels. An analysis of data at different levels would allow an evaluation of overall safety orientation performance, permitting managers to identify problem areas and concentrate resources on improving particular aspects of safety orientation. Third, the results could be used in discussions with insurers, banks and customers to make work safety more visible. Fourth, by making work safety more visible, the workforce might become more motivated in the continuous process of improving safety. Organisations should therefore regularly survey and benchmark their safety orientation and identify potential issues and improvements. By evaluating an organisation's safety culture through a survey instrument, it is possible to produce a picture of the vessel and/or ship owner at a particular point of time. This suggests that the instrument can be used to plan and implement change. The measurement of safety culture can provide management in an industry like shipping with the capacity to measure the degree to which the underlying dimensions in safety culture influence behaviour. Contextual influences such as nationality, industry culture, regulations and markets, are influencing safety culture. Further research to determine the influence of these contextual factors might improve the usefulness of safety culture scale.

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From traditional occupational safety work to systematic leisure time safety promoting

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ABSTRACT: Leisure-time accidents have become a more important problem in Finland compared to occupational accidents. As leisure-time accidents cause the same kind of negative outcomes as work-related accidents, interest in preventing leisure-time accidents has increased especially in companies with a strong safety culture. To solve companies' need for systematic methods, the researchers constructed a systematic approach (HEKOTE) to advocate safety during employees' leisure time and validated the approach in four companies. In the two case companies in which the implementation was successful, the systematic campaign had positive effects on employee leisure-time safety. At the end of the study, all four case companies were still enthusiastic about continued development of leisure-time safety campaigns.

1 INTRODUCTION

1.1 *Employers' interest in leisure-time safety is increasing*

Traditionally, Finnish companies have concentrated on preventing work (and way to work)-related accidents in advocating safety. This approach has reduced the number of work-related accidents significantly in Finland during the last 30 years (Occupational Safety 2016). However, the number of home- and exercise-related accidents has increased and become a more important problem within the past few decades. About 80% of all accidents in Finland occur during leisure time (Haikonen et al. 2010).

The negative consequences of leisure-time accidents are nearly the same for employers and employees as for work-related accidents. Employee absences require substitutes or re-organization of the work. Leisure-time accidents also cause a weakened capacity for work, as well as suffering. Serious incidents affect not only a victim negatively but also work colleagues.

Due to the negative outcomes of leisure-time accidents, employers at advanced occupational safety companies have increased their interest in finding ways to reduce staff leisure-time accidents. Decreasing the number of leisure-time accidents would benefit employees, employers and society. Forward-looking companies are willing to play their part in preventing leisure-time accidents.

1.2 *Systematic methods are lacking*

Employers have no legal obligation to promote leisure-time safety in the workplace. However, a previous study in Finland showed that the companies associated with a strong safety culture have increased interest in voluntarily advocating leisure-time safety in the workplace (Anttila et al. 2014). The idea of the employer as a leisure-time safety advocate was widely accepted by the companies and employees (Hyytinen 2012).

Previously, companies performed simple individual activities, such as distributing free reflectors and bicycle helmets, that could be defined as advocating leisure-time safety. However, the companies lacked a planned and systematic approach. Companies had, for example, no or only a vague idea about leisure-time accidents. Therefore, the companies had a need to construct more systematic methods for advocating leisure-time safety (Anttila et al. 2014).

2 MATERIAL AND METHODS

2.1 *Study design*

In this case study, a systematic approach to advocate leisure-time safety at the workplace was defined and validated in four companies. Participating companies were chosen from among the companies that participated in the previous study, related to the same topic, based on their interest and need to promote systematic leisure-time safety. The four chosen case companies represented different branches of industry (Table 1).

In the first research task, the frame of a systematic approach for advocating leisure-time safety was defined. The frame was constructed by the researchers, in co-operation with the case companies. The researchers constructed a preliminary

Table 1. Branches of case companies participating in the study.

Company	Branch
Company 1	Oil refining industry
Company 2	Rubber industry
Company 3	Maintenance services
Company 4	Metal and mining industry

version of the frame, which was presented first by visiting each case company and then in a workshop where all representatives of the companies were present. The requirement specifications for a systematic approach were established during the workshop before the final version of the frame was defined, which contained 8 phases to create a systematic approach.

In the second research task, the systematic approach was created and tested in each case company; the approach was created through the 8 phases. The researchers facilitated the companies' work groups of building a systematic approach and starting a campaign that advocates leisure-time safety at the workplace. The researchers defined the topics and schedule, but the companies made all the decisions during the project independently. The researchers also searched for information about topical subjects and presented it in work group meetings to help the decision-making. Each case company made their decisions from their own perspective. As a conclusion, the process of advocating leisure-time safety was different in every case. The frame was followed at every company, however. Therefore, the phases of building the systematic approach were the same, but details within the phases differed between the case companies.

In the third research task, information was collected about the experiences of creating a systematic approach and the effects of advocating leisure-time safety. Researchers collected experiences by observing during work group meetings. A diary was kept of all significant actions related to the topic at each case company. In addition, at the end of the study, interviews and queries were executed to evaluate the success and experiences of the cases. In each case company, the employer perspective was found through interviews and the employee perspective through query.

3 RESULTS

3.1 *Successful implementation of systematic approach*

At two of the four cases, the implementation of the systematic approach was fully successful. In these cases, this approach was integrated in the company's standard procedures. In the two other cases, a systematic approach based on collected leisure-time accident data was not achieved because the timing of the project was not best possible for the case companies. These companies had other issues, occupational safety work and organizational changes that were prioritized ahead of advocating leisure-time safety.

In the two successful cases, concrete activities were planned and implemented during the project. Leisure-time safety campaign days with changing themes were executed. Themes varied from fire safety to bicycle safety and from exercise safety to car tire safety. The case companies also added leisure-time safety issues to their regular safety trainings and produced leisure-time safety information on the company intranet. Employees were allowed to borrow personal protective equipment from the workplace for leisure time, and leisure-time safety products were distributed free of charge to staff.

3.2 *Interviews*

In total, 11 people were interviewed at the end of the project to find out the employer representatives' opinions about the project. Based on the interviews, at the end of the project the employers still supported a systematic leisure-time safety campaign. Interviewees were somewhat uncertain about the results achieved, but they agreed that the idea had a lot of potential. In their opinion, finding the most effective way to advocate and achieve the right kind of culture would take time.

Collecting information about staff leisure-time accidents was seen as a key factor in developing a leisure-time safety campaign. The more accident data, the easier it is to plan safety awareness campaigns. Lack of resources was seen as the main threat that slowed the development of systematic advocating of leisure time safety. After all, the companies' focus was still occupational safety issues, and no extra resources were provided to advocate leisure-time safety. Although the case companies performed different phases during the study, all companies still wanted to continue developing a more systematic and effective direction at the end of the project.

3.3 *Queries*

In total, 294 employees responded to the queries executed at the end of the project. Due to the companies' different development phases and practical reasons, the query of each company was slightly different. Therefore, all questions were not asked of every company's employees.

The results of the queries showed that the experiences of employees with leisure-time safety campaigns at their workplace were mainly positive. At the end of the project, most of the employees still felt positively about their employers' willingness to raise awareness of leisure-time safety (Table 2).

Most of the respondents of companies 1 and 4 agreed that they paid more attention to leisure-time safety at the end of the project than before the project (Table 3). They also agreed that their knowledge of leisure-time risks had increased during the project (Table 4).

Respondents of companies 1, 3 and 4 strongly supported continuation of the leisure-time safety campaign at the workplace. About 9 out of 10 respondents in companies 1 and 3 and about 7 out of 10 respondents in company 4 wanted the leisure-time safety campaign to continue in the future (Table 5).

The results of the queries showed that the employees' opinions were most positive in companies 1 and 4, which were the companies that successfully implemented a systematic approach during the project. Creating a planned leisure-time safety campaign jointly seems to dispel employees' suspicions and fears about the idea.

Table 2. Distribution of responses to the question "what are your thoughts about your employer's willingness to advocate leisure-time safety at your workplace?".

Company (Nr. of respondents)	Positive	Neutral	Negative
Company 1 (117)	83%	11%	6%
Company 2 (44)	30%	61%	9%
Company 3 (30)	67%	30%	3%
Company 4 (103)	71%	26%	3%

Table 3. Distribution of responses to statement "I pay attention to leisure-time safety more than before."

Company (nr. of respondents)	Agree	Disagree
Company 1 (117)	85%	15%
Company 4 (103)	88%	12%

Table 4. Distribution of responses to the statement "My knowledge about leisure-time safety risks has increased during the project."

Company (Nr. of respondents)	Agree	Disagree
Company 1 (117)	74%	26%
Company 4 (103)	73%	27%

Table 5. Distribution of responses to the statement "I want my company to continue to increase awareness of leisure time safety at my workplace."

Company (Nr. of respondents)	Agree	Disagree
Company 1 (117)	92%	8%
Company 3 (30)	90%	10%
Company 4 (103)	73%	27%

3.4 *Suggested systematic approach (HEKOTE-model)*

Based on the experience and material collected during the project, the research team constructed a suggested method for raising awareness of leisure-time safety systematically at the workplace. This systematic approach to promote safety for leisure time was named the HEKOTE-model.

The approach consisted of four modules: 1) Data gathering and data analysis, 2) Creating awareness activities, 3) Evaluating the effects of the awareness activities and 4) Communicating.

The first module is data gathering and data analysis. Leisure-time safety is a very broad topic, and it is not possible to highlight all areas concurrently. Available resources have to focus on chosen areas.

Collecting information about the staff's leisure-time accidents is an important tool to help focus. Therefore, a systematic method requires constructing a way to collect information about leisure-time accidents.

The second module is planning and creating leisure-time safety campaigns. The data collected in module 1 is important background information, which should guide the campaign for the biggest leisure-time safety problems. The planning group should include members from different personnel groups and units. Co-operation ensures that the activities are widely accepted in the different parts of the company.

An employer cannot control what employees do during their leisure time. However, with carefully planned activities, an employer may be able to change employees' leisure-time behavior by, for example, improving their knowledge and risk assessment skills. Support and help with leisure-time safety tools and protective equipment could also be valuable in preventing leisure-time accidents.

One necessary part of a systematic method is to set targets and follow up the effects of the planned and executed awareness activities. Indicators and a follow-up plan should be defined to evaluate whether the executed activities have an impact on employees' leisure-time safety behavior. A method for collecting accident information constructed in module 1 could be one tool in the follow-up and evaluation module. However, first, the reliability of the accident information collected should be ensured. If the set targets are not achieved, the campaign should be updated based on the evaluation information.

Informing staff should be included in all other modules and is specifically important in the beginning of systematic leisure-time safety campaigns. Staff may have suspicions about leisure-time safety campaigns executed by employers. Open and clear information about the reasons, targets and procedures is important for staff to get the right picture. One element of informing employees is including employees in the planning. Responding to new ideas is probably better when employees' opinions are listened to and taken into account in decision-making. Involving employees in the development phases is also one way to ensure employees are sufficiently informed.

4 CONCLUSIONS

In this case study, a systematic approach to a leisure-time safety campaign was created, piloted and evaluated. The implementation was successful in two of the four case companies. The employees of these companies experienced a positive effect on their leisure-time safety. For example, the employees experienced that their knowledge and risk assessment skills of leisure-time dangers were improved during the project.

The results show that with systematic leisure-time safety campaigns can affect staff's leisure-time safety positively. However, the extent of the positive effects and the number of prevented leisure-time accidents could not be defined during this study. Presumably, increased knowledge and improved risk assessment skills will decrease leisure-time accidents in the long run. Data could be obtained in the future with the help of companies' methods for collecting data on leisure-time accidents.

At the end of the case study, all four case companies were still enthusiastic and planned to continue developing leisure-time safety campaigns in the future. In addition, the employees strongly supported continued leisure-time safety campaigns.

Advocating leisure-time safety could increase in the future at workplaces as companies realize the potential. Advocating leisure-time safety suits specifically to companies that have decreased occupational accidents to nearly zero. In these companies, leisure-time accidents cause even more absences from work than at the average company that practices occupational safety. The results of this study should encourage companies to advocate leisure time safety at workplace. Created HEKOTE-model will help the work of interested companies on their way towards systematic advocating of leisure time safety.

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HSEQ assessment audit tool—consistency analysis of expert audits

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ABSTRACT: Health, Safety, Environment, and Quality (HSEQ) issues are often integrated into one entity in various integrated management systems. In this study, an audit tool for assessing suppliers' HSEQ performance is reviewed. The tool was developed by a set of large Finnish industrial purchasing companies. The study focused on consistency analysis wherein eight individual experts' assessments and an actual audit assessment were compared. Statistical analysis indicated that the consistency of the compared results, i.e. their agreement, was good. However, the results showed that various criteria in the tool, and the scales related to those criteria, should be improved.

1 INTRODUCTION

According to current practice, integrated management systems often encompass Health, Safety, Environment, and Quality (HSEQ) issues as one entity (Carter 1999; Kauppila et al. 2015; Koivupalo et al. 2015; Tervonen et al. 2009; Zeng et al. 2007). Large industrial purchasing companies can also consider their supplier companies' performance in an integrated way, e.g. evaluating health and safety (Ng et al. 2005) along with environment and quality issues (Kauppila et al. 2015; Väyrynen et al. 2012). This tendency is caused by the fact that supplier companies work with the purchasing companies' employees in shared workplaces, i.e. on purchasing companies' premises. Thus, the purchasing companies have a strong interest in choosing suppliers who handle their social-, economic-, and environmental affairs in a sustainable manner. Typically, suppliers operate either within a particular project or by longer-term continuous service agreement.

Purchasing companies may have dozens or even hundreds of service suppliers. The assessment of all of these is relatively expensive and very time-consuming for the subscriber company. Similarly, a supplier company is burdened by the need to learn about the practices of many purchasing companies one at a time (Väyrynen et al. 2012). Due to this, it is desirable for the purchasing company to share the assessment load among other corresponding companies. The benefits would be multifold. First, HSEQ issues could all be assessed at the same time and, second, one systematic assessment could be adopted that is suitable and acceptable for all purchasing companies. Both the purchasing companies and the suppliers would benefit.

A group of large Finnish industrial purchasing companies have developed an integrated management system for auditing their supplier companies' capabilities (Väyrynen et al. 2012; HSEQ 2017). This system includes an HSEQ assessment procedure (AP) audit tool for evaluating specific HSEQ performance factors of supplier companies (Väyrynen et al. 2016). The purchasing companies' audits focus on supplier companies that offer their services at shared workplaces and, thus, work on purchasing companies' premises. The attractiveness of a co-operative process that could ease a given purchasing company's process for auditing supplier companies' performance is one reason for purchasing companies' interest in this AP. By June 2017, 11 purchasing companies have joined the HSEQ cluster the members of which may participate in assessment processes and benefit from HSEQ results. About 150 supplier companies have already been assessed and many new HSEQ assessments are underway.

The HSEQ AP includes tools for company-specific self-assessments, audit sessions led by a lead auditor, deviation and response analyses, and final scoring (Fig. 1). In the first phase, the supplier agrees to the evaluation, and the company is registered to the assessment system. After this, the supplier company undertakes self-assessment according to 49 HSEQ criteria using an electronic assessment system. The assessment criteria are divided into the following subject areas: 1. Leadership, 2. Policy and strategy, 3. Personnel, 4. Partnerships and resources, 5. Processes, 6. Customer results, 7. Personnel results, 8. Social results, and 9. Key performance results. The third stage is the actual assessment session, wherein the HSEQ criteria are reviewed by trained appraisers from the

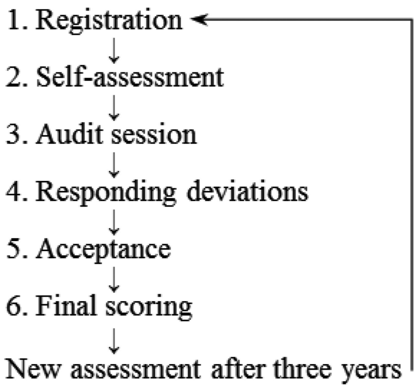

Figure 1. The phases of the HSEQ AP.

purchasing companies and representatives of the supplier company. The assessment is conducted according to a four-step maturity scale. The results of the supplier's self-assessment are also on hand in the audit session. Supplier companies are required to supply documented information to support decision making. In addition, the audit is carried out on the supplier's premises. If the supplier company does not pass any of the assessment criteria, this deviation will be noted, and the necessary changes in the company's operations must be made within a given time. In the fifth phase, the answers to the deviations are reviewed, and the results are accepted. In the sixth phase, the final score of the supplier company is obtained. The assessment is valid for three years, after which the supplier must be re-evaluated using the same procedure.

2 MATERIALS AND METHODS

In this study, we focused on the audit session (see Fig. 1), which is the most important phase of the AP. We analyzed whether the HSEQ assessment criteria and the four-step maturity scale are sufficiently easy to understand that the auditors can give consistent results.

Audit assessments conducted by eight accepted experts were compared for each of the 49 HSEQ criteria included in the assessment tool. Our analysis is based on a video-recorded real-life supplier audit session in which representatives from the supplier company provided their views on the assessment criteria. The video was independently analyzed by eight experts who watched it and provided audit scores for each question. So the results provided by the experts relate to the experimented implementation, and the results of the audit group are actual assessment results.

The results were processed using Excel. In addition, Minitab 18 was utilized for attribute agreement analysis, both among the experts and between the experts and the actual audit results.

3 RESULTS

We compared the results in two ways. First, the responses of the experts were compared to the responses of the assessment group, and second, the responses of the experts were compared with each other.

3.1 *Comparison of results between experts and audit group*

Each expert provided his or her own answers to the criteria (49), so a total of 389 reviews were submitted (49 criteria x 8 experts; only 3 responses were missing). Of these reviews, 284 (73.0%) were identical to the audit group (Fig. 2). There were 100 reviews that differed in one step from those of the audit group (25.7%), and they fluctuated evenly on both sides of the audit group's outcome. Assessment differences of more than one step were given only five times, and they were two steps weaker than the results of the audit group. These five assessment results were divided between three different criteria so that three experts gave a lower result by two steps for one criterion and one expert gave a lower result by two steps for two criteria.

All eight experts agreed with the audit group in 13 criteria (Table 1). In addition, seven experts gave the same results as the audit group in four criteria and six experts gave the same results in 14 criteria. Altogether, there were five criteria in which under the half of the experts agreed with the audit group.

3.2 *Comparison of results among the experts*

When the results of the experts are compared in each criterion (49) it can be seen that all of the experts gave the same answer to the 13 criteria (Table 2). In five criteria, seven experts ended up with the same assessment result, and in 15 criteria, six experts did so. There were eight criteria in which only half of the experts ended up with a congruent result. Only one criterion was weaker than this convergence. In this case, three experts assessed their result to the second level, three experts to the third level, and two experts to the highest level.

As previously stated, a total of 389 expert assessments were given. Of these, 299 (about 77%) were consistent with the majority (Fig. 3). One-level (+/−1) differences compared with the majority were given in 88 assessments (22.6%). Only twice

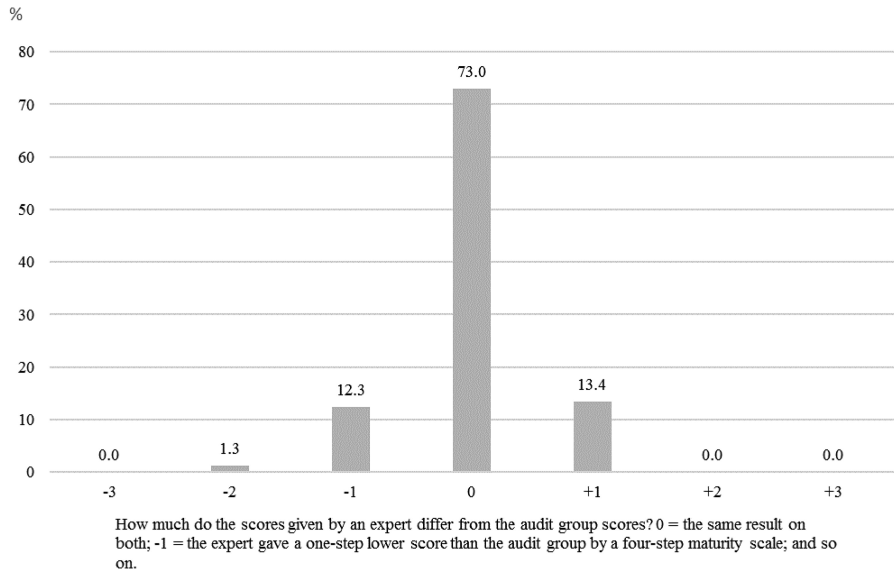

Figure 2. The percentage indicates what portion of the assessments provided by the experts were the same, lower (–), or higher (+) than those of the audit group and by how many steps they differed in the four-step maturity scale.

Table 1. The table shows how many experts gave the same answer to each criterion as the audit group.

	Number of criteria
All 8 experts gave the same scores as the audit group to the criterion	13
7 experts gave the same scores	4
6 experts gave the same scores	14
5 experts gave the same scores	5
4 experts gave the same scores	8
3 experts gave the same scores	2
2 experts gave the same scores	2
1 expert gave the same scores	1
Total	49 criteria

Table 2. The table shows that how many experts provided the same result for each criterion.

	Number of criteria
All 8 experts gave the same scores to the criterion	13
7 experts gave the same scores	5
6 experts gave the same scores	15
5 experts gave the same scores	7
4 experts gave the same scores	8
3 experts gave the same scores	1
Total	49 criteria

did the assessment vary more than one level from the majority in the assessment scale.

3.3 *Statistical analysis*

The consistency of the results of eight experts and the real assessment result was analyzed with the help of attribute agreement analysis in Minitab 18. The assessments of each of the eight experts strongly correlated with the actual assessments (Kendall's tau, $p < 0.001$). Kendall's tau for all of the experts vs the real audit results was 0.69 ($p < 0.001$), and among the experts, it was 0.71 ($p < 0.001$). The analysis showed that one expert had assessed all criteria the same way as the audit group, and one expert had assessed slightly over half of the criteria otherwise (51%).

4 DISCUSSION AND CONCLUSIONS

In the light of this study, a critical review should be conducted of three criteria wherein some experts assessed results two levels lower than the audit group (Fig. 2). In one of these criteria, up to three experts gave their assessment at two levels below the audit group. It is noteworthy that three experts gave a one-level-lower assessment of the same criterion. In addition, the criteria should be considered wherein only one to three experts agreed with the assessment group (Table 1). There were five such criteria, and

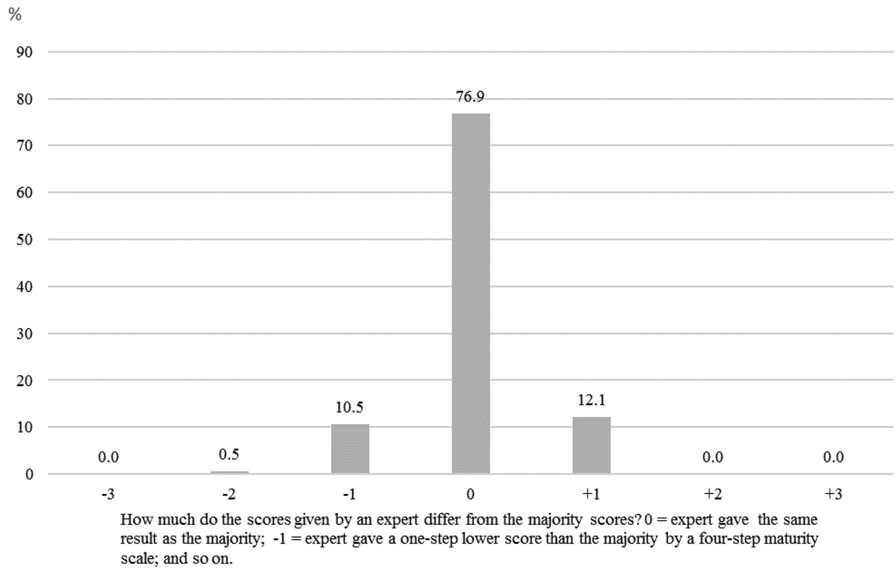

Figure 3. The percentage indicates what portion of the assessment results provided by the experts were the same, lower (–), or higher (+) than the majority and by how many steps they differed in the four-step maturity scale. If the results of eight experts were evenly divided for two assessment levels, the "majority" was determined according to the audit group's result.

only one was the same as those mentioned in the previous paragraph. However, it is recommended that all of the criteria be reviewed wherein one to five out of eight experts ended up with the same result as the audit group. There were 18 of those.

In the study, the criteria with the weakest consistency in the expert comparison should be reviewed. For example, in 15 criteria, a majority was formed by the group of four to five experts and, in one criterion, a majority was formed by a group of only three experts (Table 2).

All criteria above should be checked in terms of both questions and assessment levels. If necessary, these should be changed to be clearer and more explicit. Assessment guidance needs to be improved, and the evaluator education should pay particular attention to these criteria.

As a whole, the results showed that a majority of the experts mostly interpreted the HSEQ assessment criteria and a four-step maturity scale the same way as the audit group. However, only 13 HSEQ criteria out of 49 got the same scores from all of the experts and the audit group, and in five HSEQ criteria, more than half of the experts disagreed with the audit group. In the cases of divergent interpretation, the divergences were mainly one step in both comparisons (Figs 2–3). The statistical analysis showed that there is good agreement between the eight experts as well as between all experts and the actual audit results. However, the problematic criteria should be carefully examined.

The HSEQ cluster has already changed some of the assessment criteria. It would be productive to consider, based on this study, which criteria still need clarification. This will ensure the improved consistency of all forthcoming assessments.

When evaluating the results of the study, it should be noted that only one supplier company's audit session was utilized in the study. In addition, only eight experts assessed this supplier company. Due to these considerations, the results should be considered preliminary and must be interpreted with special care.

This kind of study should be repeated with new supplier companies and a few additional experts. Additionally, the homogeneity of experts could be increased by including only the lead auditors, who have been trained in the use of HSEQ AP and who have been involved in many audit sessions. These considerations would improve the reliability of the study and provide additional value to the research result.

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Capturing lessons learnt from an accident investigation to improve the management of geological hazards in construction

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ABSTRACT: The paper presents a case study of the capturing of experience from an accident involving rock slide during the rehabilitation of a 22-km road segment. It builds on results from the accident investigation and a follow-up audit one year after the accident and on interviews with personnel in the Client Company on the use of the experiences in future projects. Data are analysed in relation to a model for evaluation of interventions. It is concluded that the involved parties in the project had the ability to capture lessons learnt and coordinate their efforts to complete the rehabilitation work in a safe and controlled way. The assessment of the Client Company's ability to capture the knowledge for transfer to new projects showed more varying results. Different constraints to an efficient experience transfer to new projects were identified. These included limited personnel overlap between the project and the basis organisation in the Company and a document structure representing the Company's experience carriers to future projects that was not fully suited to capture the complexity of the solution.

1 INTRODUCTION

The construction industry is generally characterized by a high risk of severe accidents. The fatal accident risk is according to an ILO estimate five times higher for employees in this industry compared to the general average for employees worldwide (Murie 2007). ILO also estimates that one in six of the fatal work-related accidents globally occurs in construction (Wells and Hawkins 2010). Statistics from 2009–2014 in Norway showed that the fatal accident frequency among construction workers was about three times that of the general average among employees in Norway, only surpassed by employees in primary activities such as agriculture, fishing, logging and mining (Arbeidstilsynet 2015).

Learning from experience to improve future performance is a primary strategy in the management of safety (Kjellén 2017). In the construction industry, tasks are organised in a project with limited duration. Build-up of experience and learning takes place in the project, but the project organisation is dissolved after completion of the project, and it has turned out to be difficult to utilize the lessons learnt in new projects (Ozorhon et al. 2005; Brady and Davis 2004). The achieved knowledge is not communicated to the basis organisation of the construction company or the client company and shared within the respective organisation. Generally, the construction industry is characterised by a culture of aversion towards standardisation of work performance through rules and procedures (Swuste 2012). These are important carriers of experience. The fragmented responsibility for safety between the designer and the construction company, and lack of feedback to the designer on experiences in construction, also contributes to the difficulties in accomplish an efficient management of safety through experience feedback.

The organisational memory is a corporate asset that is developed through contributions of individual members of the company (Ozorhon et al 2014). This requires routines for capturing, organisation, storing, dissemination and reuse of the experience and knowledge achieved through the members' participation in construction projects. Nonaka and Takeuchi (1995) have analysed how knowledge is created at the organisational level through a "learning spiral", where experience is exchanged between the members of the organisation. The process that make up the learning spiral apply well to the management of safety, for example in accident investigations, where the investigation itself represents a turn of the spiral and the development of remedial actions a second (Kjellén and Albrechtsen 2017). In an investigation, individuals' tacit experience from the accident is shared with the investigators through so-called socialisation. The original experience is subjective and context dependent. The investigation team analyses this experience by articulating and de-contextualise it and combining it with other information, and makes it explicit and available to the organisation through documentation. In the next turn, the explicit knowledge is made available to the construction site organisation and internalised by its members for implementation, and their experience is fed back in a similar process.

The learning spiral, when applied to the construction industry, requires a certain size and organisation of the involved companies. The client company is in focus here, since it is as project owner overall responsible for the execution of the project, but the same applies to the construction company and the consultant involved in design. Each company needs to have a so-called techno structure with a basis organisation e.g. at the home office, from which a significant part of its project organisations is recruited (Sandven & Vik 2013). The company employees in the project report in a matrix to the project and the basis organisation in parallel, and are members of a community of practice of the company within their respective field of expertise (Nonaka 1994). These communities will accumulate the experiences made by their members in different projects and ensure that it i made available to the organisation to improve work performance.

1.1 *This paper*

This paper presents a case study of the transfer of experience from an accident involving a rock slide during rehabilitation of a road as part of the construction of a hydropower plant in Albania. The accident occurred during scaling work to secure loose boulders with potential to fall on the road. The rock slide came as a surprise to the personnel involved in the planning and execution of the road work due to an inadequate understanding of the geology in the specific area of the accident. The investigation showed that the planning and execution of scaling work deviated from best practice for such work developed in other parts of the client's organisation. This experience emphasises the difficulties in capturing experience in one part of a large company and making it available throughout the organisation.

The aim of the paper is to review experiences from the subsequent investigation and follow up of the rock-slide accident on how to capture lessons learned on the management of construction work with major accident potential from an organisational learning perspective. It addresses the following questions related to the presented case:

1. How did the scaling work resulting in a fatal accident differ from the best practice established for this type of work?
2. What were the lessons learnt from the investigation into the fatal accident?
3. How were lessons learnt implemented in the completion of the rehabilitation of the canyon road?
4. What effect did the implemented changes have on performance related to safety, progress and cost?
5. How were the experiences made available for use in future projects?

2 CASE DESCRIPTION

The paper builds on experience from the planning and execution of scaling and rock support work during rehabilitation of a 22 km road segment between Kodovjat and Moglicë in Albania. This road segment, located in the canyon of the Devoll River, has been carved out of the steep mountain on the right side of the river bank. The road was originally built in the beginning of the 1950's, and the road construction project at that time suffered from in the order of 30 fatalities due to accidents. The canyon is prone to rock fall and rock slide. The geology in general in the canyon is extremely challenging resulting in slope instability. The rock in the canyon is highly-fractured Peridotite with joints of low friction due to clay mineral and water.

The canyon road represents the main access to the construction site of the Moglicë hydropower plant. The plant belongs to Statkraft (hereinafter named "Company"), a Norwegian state-owned power company. During planning of the Moglicë Hydropower plant, it was considered necessary to rehabilitate the road. The original road was too narrow and too exposed to slope instability hazards to serve as access road for the frequent and heavy traffic during the construction period of the plant.

In an agreement with the Albanian authorities, the Company took responsibility for the required rehabilitation and improvement of the road segment. The concept and method of implementing the works on the road segment was initially limited to rehabilitate and improve the existing road. Road construction work started in July 2013 but was soon thereafter stopped due to constructability issues. Due to the very challenging geology, the work was subject to repeated redesign until it became clear that the only feasible design was far more extensive than initially assessed.

In the period required for extensive redesign of parts of the road, the work to secure the road from geological hazards and some minor road widening and other improvement work continued. During securing work, three professional scalers removing loose rock were killed by a major rockslide in April 2014.

In the investigation by the Company following the accident, it was recommended to change the method for road work by improving control of the geological hazards and ensure safe advancement of work considering the danger zone of falling rock. Construction was re-started in October 2014 by applying the recommendations and the rehabilitation of the Kodovjat—Mogličë road segment was finally completed in early autumn 2015.

3 MATERIALS AND METHOD

3.1 *Analysis framework*

The overall framework for analysis used in this paper is shown in Figure 1. It represents an adaptation of a model used to evaluate interventions (Shannon et al. 1999). A main aim of the accident investigation was to map gaps between established best practice within the Norwegian part of the company in executing scaling and rock support work and how it was executed in the situation resulting in a severe accident in the project in Albania (RQ1, see Section 1.1). The intervention is represented by the recommendation of the investigation team to the project on how to manage the work in question, and to ensure safe execution (RQ2). Materials to answer RQ3 and RQ4 were collected in an audit conducted approximately one year after the accident. It covered the recommendations that had been implemented and how. The audit team also studied the immediate effects on change of behaviour and the intermediate effects regarding frequency of accidents and unwanted occurrences. Cost and schedule effects were also included in the evaluation.

The question on how the company secured that the experience from the investigation and follow up were made available to new projects (RQ5) were covered for this paper by separate interviews.

3.2 *Data sources*

The main sources of data for this case study are the reports from the investigation into the accident and the follow-up audit one year after the occurrence. These data are complemented with data from project cost and progress reports, the project's incident database and general experience by the authors. To answer RQ5, complementary interviews have been conducted with company personnel with key insight into the question.

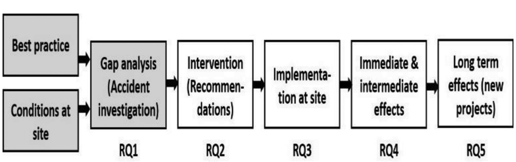


Figure 1. Overall analysis framework. The research questions (RQ) referred to are shown in Section 1.1.

3.2.1 *Accident investigation*

The Company has established a system of investigations at three levels, dependent on the actual or potential severity of the accident. A Level 3 investigation is limited mainly to accidents with fatal (actual or potential) consequence. Such investigation is conducted by an independent team appointed by the business area manager. The investigation for this case study was led by the HSE manager of a subsidiary, and the team was made up of a scaling and rock support specialist from a Norwegian contractor together with a geologist of a subsidiary and a construction manager from the Company. None of the team members had worked with the project from before.

In the investigation, 26 persons were interviewed from the project, owner's engineer, owner's designer (geologists), the road contractor and a sub-contractor for scaling work. The investigation also included site visits and document reviews of relevance to the investigation.

The applied method entailed a stepwise process of investigation (Kjellén & Albrechtsen 2017). In the first step, the conditions around the accident and the sequence of events were mapped. The mapping of the sequence of events included the road history starting with authority approval of the road upgrade, and ending with the detailed sequence of events of the day of the accident including emergency handling. This step also included barrier and deviation analyses in the execution of the work. A special analysis was dedicated to an interpretation of the geological conditions at the site and possible causes of the rock slide that killed the three scalers.

The next step focused on influencing factors in the work system and at the work site. Arrangements for execution of scaling work was studied in detail and compared to the best practice presented in Section 4.1.

The subsequent step focused on root causes in the management systems of the contractor and the Company and how they affected the conditions at the work place, execution of work, the accident sequence and loss. The investigation was carried out based on the principles of quality audits according to ISO 19011:2011 (ISO 2011).

3.2.2 *Follow-up audit*

The aim of the follow-up audit was to assess the project's implementation of the recommendations from the Level 3 investigation of the fatal accident. The Lead auditor was the same person that led the Level 3 investigation. He was accompanied by a geologist from the Company (not the same person as in the Level 3 investigation). The audit was carried out according to ISO 19011:2011 and included interviews, site visits and document reviews (ISO 2011). In the audit, 21 persons were interviewed from the project, owner's engineer, the road contractor and hired scaling specialists and geologist by the contractor.

3.2.3 *Interviews of members of the Company's project organisation*

The authors have conducted interviews for the preparation of this paper with the engineering manager of the Company's basis department for projects and construction at the head office and with two members of an ongoing wind project in Norway involved in road construction with significant slope instability issues. The purpose has been to explore whether and how the experience from the investigation has been made available for future projects.

4 MANAGEMENT OF HAZARDOUS WORK

Scaling work involves hazards with potential to cause significant harm and as such must be executed in a controlled way. It falls under Annex II in EU Council Directive 92/57/EEC of work involving particular risks including risk of burial aggravated by the nature of the environment at the place of work (European Council 1992). It is thus not sufficient that the method of work is left at the discretion of the workers at the sharp end but must be defined and managed at an organisational level (European Council 1992; Borys, 2012). It has become common in the construction industry to apply so-called Method Statements for this purpose. A method statement is not required by law, but is an efficient means to fulfil the requirements, e.g. in the Council Directive 92/57/EEC (HSE 2006). It governs a commonly agreed approach to execution of the work between the involved parties and individuals. It is based on a risk assessment and describes in a logical sequence the steps to execute the work safely and the preconditions including qualifications of personnel, type and quality of machinery and tools.

A Method statement fulfils the purpose of an experience carrier in the organisational memory of a construction company. It represents a means of developing and storing experience from accidents and unwanted occurrences by a community of practice according to the principles of Nonaka's learning spiral as outlined in Section 1.

The Company had the intention to ensure that high-risk construction activities were executed in a safe way. An ideal process to accomplish this is shown in Figure 2. The site-specific conditions and conditions related to the contract object are identified in the feasibility study phase and transferred by the Client to the Construction Contractors in the invitation to tender for the work. The Contractors are required to submit preliminary

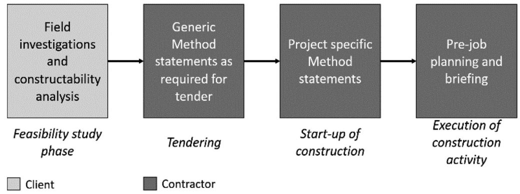


Figure 2. Idealized process to define safe execution of high-risk construction activities.

Method statements in the tender for the construction activities as defined by the scope of work. The information submitted with the tender is used to check the Contractors' technical qualifications and understanding of the scope of work throughout the process of tender evaluation, bid clarifications, and negotiations before contract award. The successful Contractor must deliver updated Methods statements for the specific project before start-up of construction. Finally, the conditions at the specific site of work including temporary conditions such as weather are considered in a Job Hazard Analysis in pre-job planning and briefing of the construction workers before a specific job is started. The method statements provide the Client with transparency in quality assurance of Contractor's work plans, preparations and job execution.

4.1 *Management of scaling work*

The best practice for execution of scaling work within the Company's Norwegian operations was mapped in the preparation for the investigation. This was done in cooperation with the manager of a specialised department for scaling work of a large Norwegian contractor. This department had previously been involved in scaling work for the Company.

The approach used for the management of scaling work was not documented by the Company in Norway. A basic requirement was that all scaling personnel should move into the slope to be scaled in a way that kept them outside of the danger zone for falling rock or slope failure when they removed rock and stabilised the slope. This basic rule complies with Haddon's strategy no. 6 for accident prevention (Haddon, 1980).

The approach may be summarized in the following points:

- The scalers performing the work must be experienced and be able to document training on the equipment used in the work. For demanding terrain, two of the scalers need to be senior.
- Before any physical work, the rock-fall hazards and the slope stability of the area shall be documented in a geological Memo. It shall

also describe the design of rock support measures and slope stabilisation materials and how and where these shall be implemented in the area.
- There shall be a Method statement based on a detailed risk assessment for the area to be scaled and secured.
- Both the geological Memo and the risk assessment shall be presented to and discussed with the scalers.
- Work shall not be executed under unfavourable weather conditions. This will require evaluation of weather forecast, monitoring of data and stoppage of work in case of precipitation above a pre-defined threshold.
- The scalers shall work from a position that is judged to be safe and outside of the danger zone for falling rock and land-/rockslide when they remove loose rock and stabilise the slope.
- The Company's project representing the Client is responsible for ensuring qualified input to the geological Memo. The geologist responsible for the Memo must check and supervise the work while it is performed.

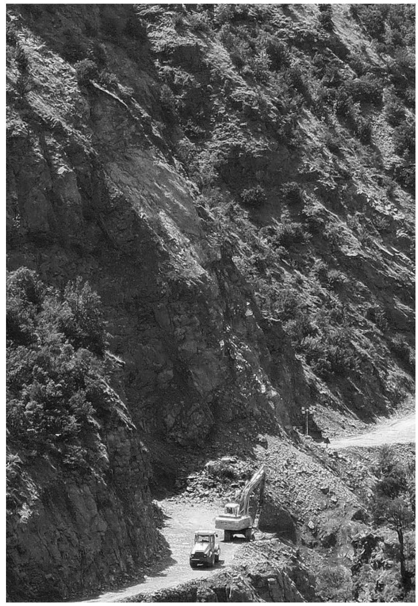


Figure 3. The rock-slide area after the accident.

5 RESULTS

5.1 *Accident investigation*

5.1.1 *The accident*

The area of the rock-slide accident after the rock slide had occurred is shown in Figure 3. At the time of the accident, three employees of a scaling subcontractor to the road contractor were engaged in manual scaling of loose rock when a section of the slope started to slide. All three scalers were secured by rope; two of them to the section that slid and the third (the supervisor) to a tree at the top edge of that section. The two scalers attached to the sliding section were dragged down to the river bed and the supervisor was found hanging in his rope at the top of the slide. All three scalers perished because of the rock slide.

While executing their work, the scalers were focussing on removing loose rock. They did not have access to written information, and likely did not understand the global geological conditions at the slope and the risk of a major rock-slide in the area that they were scaling. The slide involved a section of rock formed as a wedge with approximately 65-degree inclination. In this type of rock formation, there is a reduced friction along the joint surfaces due to clay and intrusion of fine roots. Water due to heavy rain will reduce the friction further.

Heavy rain on the day of the accident and in the previous days had increased the risk of rock-slide. The underlying cause for the slide to happen is still not fully known, but there is a good record of the activities before the incident. An excavator equipped with a hydraulic rock breaker started chiselling the slope below the slide area in the morning and may have destabilised the rock section. It is also possible that the scaling team may have removed "key blocks" (critical supporting blocks) and by that destabilised the slope.

5.1.2 *Deviations from best practice*

The investigation revealed several deviations in the scaling work on the day of the accident both from the road upgrade contract focusing on requirements to controlled and safe work execution and from the best practice outlined in Section 4.1:

- Of the three scalers performing the work, only one of the scaler (supervisor) had long experience (>25 years). Normally, two senior scalers are required for scaling in an area with demanding geology. None of the scalers had documented training on the equipment used.
- Whereas loose rock that needed to be removed from the area had been identified, the global geological conditions had not been adequately evaluated and communicated to the scaling team. The geological survey for the revised design of the road including rock support had not been finalized when the scaling work was performed.
- The Method statement for scaling work developed by the subcontractor and the associated risk assessment were too generic and did not address the specific hazards in the area to be scaled.

- The project did not monitor the precipitation and did not have any criteria for stoppage of work exposed to the risk of rock-fall or slides in case of heavy rain. There had been heavy rain in the area immediately prior to the accident. A weather station 34 km away showed a precipitation of 10 mm on the day of the accident.
- The excavator driver reported rock falls from the area in the morning and requested the scalers, but this information did not trigger a risk assessment prior to the start of scaling.
- The team of three scalers, out of which one supervised the work, were all located in the danger zone of rock-slide when the accident occurred. The supervisor was positioned on the top of the rock-section that gave away. The two other scalers were working below the same section and were at its lower edge when the slide started.
- No qualified geologist was checking and supervising the scaling work.

5.1.3 *Recommendations*

The investigation team's recommendations addressed the identified deviations. These included:

- The development and documentation of an overall strategy by the project for moving forward in the canyon in a controlled way based on the principles of avoiding road construction work including scaling in the danger zone of slope instability hazards.
- Detailed geological mapping including design of site specific rock-support measures had to be prepared and approved before start of each new section of road construction work.
- The scaling subcontractor had to develop a specific risk assessment and Method Statement for the scaling work in the Canyon including procedures for the handling of equipment and qualifications to personnel.
- A site-specific risk assessment and Method statement had to be developed for the scaling and rock support work of each section of the road as a basis for the daily crew briefing before start of work.
- The preparations had to be quality controlled by the geologist, who also supervised the work.
- The scalers were subject to documented training and approval by an authorised scaler before starting to work for the project.
- An automatic, 24 hrs online weather monitoring station was installed adjacent to the construction area and stop criteria for work based on precipitation (mm/hr and duration) was established.

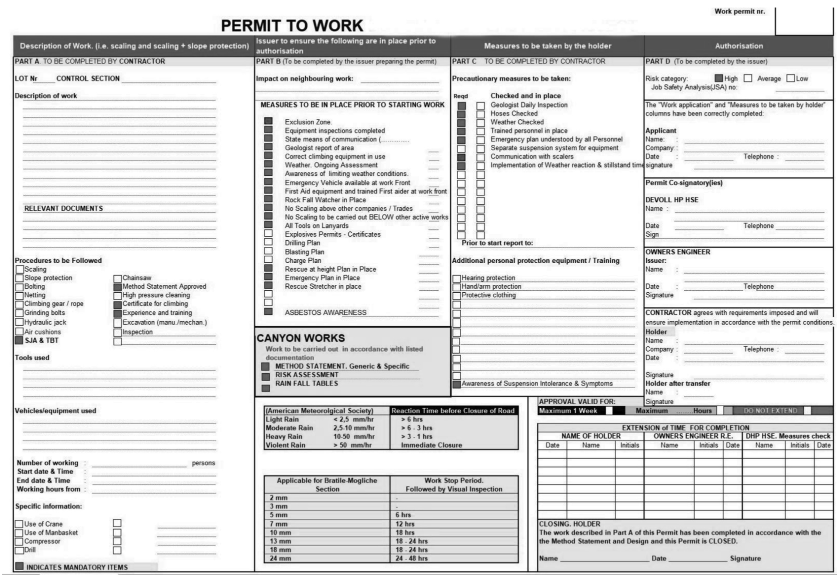
5.2 *Implementation of recommendations in the project*

The status of implementation was checked in the audit performed about a year after the accident. At that time, scaling work had been completed and slope stabilization and road widening work was ongoing. That means that the audit assessed the scaling work in retrospect.

The audit concluded that the project including the road contractor had followed-up on the recommendations in a satisfactory way. The recommendation to develop an overall strategy for safe moving forward in the canyon had been implemented through a procedure to divide the canyon road into sections of 25 m. Work had to move forward in a controlled way from section to section by use of a permit-to-work (PTW) system with measures that had to be defined and implemented before work in a section could start. The form identified measures to be considered based on the principles of ensuring operational readiness, i.e. personnel, equipment and procedures ready and environment checked and considered adequately safe to proceed. The PTW system was based on general principles for such systems (see e.g. HSE 2005). It defined the work flow and responsibilities in application for PTW, review and approval. A PTW form was introduced and used in documenting the identification, approval, implementation and verification of pre-defined measures, and the execution and close out of work, Figure 4.

In developing and implementing the strategy, the responsibilities of the different parties, being the Owner's Designer (OD), the Owner's Engineer (OE), the Company and Contractor had to be clearly defined and understood by the different parties. Scaling and rock-support work were based on detailed geological mappings by geologists from OD and OE. The road Contractor participated in pre-construction inspections of each section together with the geologists and the client to finalize design, before the Contractor could start to develop the required detailed risk assessments and method statement for the section.

The road Contractor had developed a "generic" method statement and risk assessment for the scaling work in the canyon. It detailed the requirements to qualifications and physical fitness of the scalers, requirements to equipment to be used and requirements to preparation and execution of scaling work. Contractor also developed a site-specific method statement including a risk assessment for each control section as an attachment to the PTW application. It included a geological assessment and detailed sketch of the work sequence by the OD geologist. The measures to be in place before start of work were defined and checked in the PTW form by the OE resident engineer and the project's HSE inspector. They were reviewed by the OD geologist and finally verified in the field by the project HSE inspector and approved before


Work permit nr.

PERMIT TO WORK

Description of Work. (i.e. scaling and scaling + slope protection)	Issuer to ensure the following are in place prior to authorisation	Measures to be taken by the holder	Authorisation
PART A. TO BE COMPLETED BY CONTRACTOR	PART B (To be completed by the issuer preparing the permit)	PART C TO BE COMPLETED BY CONTRACTOR	PART D (To be completed by the issuer)

PART A: LOT Nr ____ CONTROL SECTION ____
Description of work
RELEVANT DOCUMENTS
Procedures to be Followed: Scaling; Slope protection; Bolting; Netting; Climbing gear / rope; Grinding bolts; Hydraulic jack; Air cushions; SJA & TBT; Chainsaw; Method Statement Approved; High pressure cleaning; Certificate for climbing; Experience and training; Excavation (manu./mechan.); Inspection
Tools used
Vehicles/equipment used
Number of working persons; Start date & Time; End date & Time; Working hours from
Specific information: Use of Crane; Use of Manbasket; Compressor; Drill
INDICATES MANDATORY ITEMS

PART B: Impact on neighbouring work:
MEASURES TO BE IN PLACE PRIOR TO STARTING WORK: Exclusion Zone; Equipment inspections completed; State means of communication (............; Geologist report of area; Correct climbing equipment in use; Weather. Ongoing Assessment; Awareness of limiting weather conditions; Emergency Vehicle available at work Front; First Aid equipment and trained First aider at work front; Rock Fall Watcher in Place; No Scaling above other companies / Trades; No Scaling to be carried out BELOW other active works; All Tools on Lanyards; Explosives Permits - Certificates; Drilling Plan; Blasting Plan; Charge Plan; Rescue at height Plan in Place; Emergency Plan in Place; Rescue Stretcher in place; ASBESTOS AWARENESS

CANYON WORKS
Work to be carried out in accordance with listed documentation
METHOD STATEMENT. Generic & Specific
RISK ASSESSMENT
RAIN FALL TABLES

(American Meteorolgical Society)		Reaction Time before Closure of Road
Light Rain	< 2,5 mm/hr	> 6 hrs
Moderate Rain	2,5-10 mm/hr	> 6 - 3 hrs
Heavy Rain	10-50 mm/hr	> 3 - 1 hrs
Violent Rain	> 50 mm/hr	Immediate Closure

Applicable for Bratile-Mogliche Section	Work Stop Period. Followed by Visual Inspection
2 mm	-
3 mm	-
5 mm	6 hrs
7 mm	12 hrs
10 mm	18 hrs
13 mm	18 - 24 hrs
18 mm	18 - 24 hrs
24 mm	24 - 48 hrs

PART C: Precautionary measures to be taken:
Reqd / Checked and in place: Geologist Daily Inspection; Hoses Checked; Weather Checked; Trained personnel in place; Emergency plan understood by all Personnel; Separate suspension system for equipment; Communication with scalers; Implementation of Weather reaction & stillstand time
Prior to start report to:
Additional personal protection equipment / Training: Hearing protection; Hand/arm protection; Protective clothing; Awareness of Suspension Intolerance & Symptoms

PART D: Risk category: High / Average / Low
Job Safety Analysis(JSA) no:
The "Work application" and "Measures to be taken by holder" columns have been correctly completed:
Applicant: Name; Company; Date; Telephone; signature
Permit Co-signatory(ies)
DEVOLL HP HSE: Name; Date; Telephone; Sign
OWNERS ENGINEER Issuer: Name; Date; Telephone; Signature
CONTRACTOR agrees with requirements imposed and will ensure implementation in accordance with the permit conditions.
Holder: Name; Company; Telephone; Date; Signature
Holder after transfer: Name; Signature

APPROVAL VALID FOR: Maximum 1 Week / Maximum ... Hours / DO NOT EXTEND

EXTENSION of TIME FOR COMPLETION									
NAME OF HOLDER			OWNERS ENGINEER R.E.			DHP HSE. Measures check			
Date	Name	Initials	Name	Initials	Date	Name	Initials	Date	

CLOSING. HOLDER
The work described in Part A of this Permit has been completed in accordance with the the Method Statement and Design and this Permit is CLOSED.
Name ____ Date ____ Signature

Figure 4. PTW form used by the project.

start of work. All activities were traced in a PTW form for each section of the road.

The scaling subcontractor started daily work by briefing the crew in a tool-box meeting about the day's work. The detailed method statement was presented and signed by the participants. The OD geologist participated in these meetings and supervised the work during execution.

A procedure had also been established to control access to the canyon road for construction work including scaling and transportation. Work was stopped during unfavourable weather conditions based on data from a project-specific weather station and opened after inspection by a road patrol and consent by the OD geologist.

5.2.1 *Incident statistics*

In total four accidents have been registered in the canyon road during 2014–15. Scaling work on the canyon road started in February/March 2014 and continued until the fatal accident in 29th of April. During this period, there was one additional recordable injury when a flag man was hit by falling rock. No injuries have been recorded in the period October 2014 – early autumn 2015, when the road was completed. Two traffic related accidents occurred late 2015 on the road.

In the investigation of the fatal accident, the team analysed rock fall and land slide incidents in a period of 35 days. Due to the concerns on slope instability issues, the project collected regular data on rock fall incidents until work stopped on April 29, 2014. In ten of these days rock falls and landslides were reported, mostly in conjunction with heavy rain. There was one major landslide of approximately 1000 m^3 before the accident.

There were no similar systematically collected statistics for the road construction period when work was resumed in the autumn of 2014, because slope instability was not considered as critical.

5.2.2 *Cost and schedule impact*

Work on the canyon road was stopped immediately after the accident on April 29, 2014 and was only resumed in the beginning of October in the same year. The five months period was used for geological mapping and redesign of the road and for implementation of the recommendations of the investigation team. These were available to the project in a draft version less than two week after the accident and in a final report from the investigation team three weeks later.

The additional delay in the start-up of road rehabilitation due to development and implementation of the recommendations has been roughly estimated to be 20 weeks. During the period May–September one of the members of the investigation team, a scaling and rock support specialist, was hired by the project as a consultant to support in developing method, work process and documentation, and training to qualify scaling personnel to be used by the project. The investigation team leader also interacted with the project in elaborating on the recommendations and assessing solutions. A critical issue during the development of remedial actions was the need to define the split of responsibilities for safety that followed the signing the PTW form and Job Safety Analysis of the scaling work between the project owner (Company), OD and OE and the Contractor. The OD and OE consultants were not used in the past to take a direct responsibility for the safety consequences of their advice and assessments in a way that was required by the new system.

It took the project another 11 months to finalize the rehabilitation of the canyon road. The delay in progress during this period due to the new strategy for moving forward in the canyon and the imposed restrictions in work due to weather conditions has been estimated to four months.

The original budget for rehabilitation of the canyon road was 15 million Euro. The final calculation after completion of the project showed a total cost of 32 million Euro. This included costs for delays and changed methods of work and also costs for the new geological mapping, redesign and implementation of the new design.

5.3 *Capturing of lessons learnt for use in future projects*

The Company's projects and construction department is responsible for the development of internal instructions and specifications used in contracting and execution of construction work. These serve as carriers of experience from previous projects. A review of the department's specification for contractors' management of HSE in construction showed traceable evidence of input from the investigation and the road project's follow-up of it. This especially applied to the requirement to implement a permit-to-work system for work exposed to geological hazards and requirements to risk assessment based on geological mapping. The experiences regarding weather monitoring were also implemented in this specification.

The department had also developed new internal instructions for review of method statements and quality assurance of high-risk work before start-up, much in line with the experiences from the investigation.

Lessons learnt from the investigation were less visible in the department's specification for Civil Works, because this document is focusing on technical requirements to materials and final product, and to a lesser degree gives guidelines on execution of work by the Contractors. The lessons learnt were incorporated in the specification by demanding detailed Method statements from the Contractor prior to executing stabilization works. A strategy and criteria for how these Method statements are evaluated and approved by the Client is therefore required to be described in another document than those forming part of the contract documents. The follow up by the project on how to safely move forward section-by-section in upgrading an existing road with significant slope instability hazards had not been implemented in any "experience carrier".

The Company's projects and construction department lacked adequate carriers of experience related to the technical management and follow-up of Contracts by the different disciplines, where such experience could be implemented. This work was largely outsourced to an OE Consultant that reported to the technical manager of the project, and the experience followed the Consultant's personnel to new projects.

The Norwegian wind project that was selected for interviews (Section 3.2.3) had experienced significant challenges related to slope instability in conjunction with road construction and upgrading. Experiences from the fatal accident in the canyon road were very evident in the project, including in an experience workshop where this case was discussed. Because the slope instability issues only were concentrated to shorter sections of the road, the wind project had not found it necessary to implement a comprehensive strategy for moving forward along the roads and no detailed method statements and permit-to-work system were implemented. The most significant learning from the canyon road accident was the need of close cooperation between geologists and the civil contractor. As in the canyon road projects, geologists were present and supervised the work at critical road segments with respect to slope instability.

6 DISCUSSION

The case study describes an example from road rehabilitation of the intervention process outlined in Section 3.1. In this case, the intervention process was triggered by a severe accident. The process included the accident investigation and follow up through development and implementation of recommendations in the affected project and the capturing of the lessons learnt for use in new projects. The study object was a road rehabilitation project with significant safety issues related to topography and geology. The case study demonstrates that the project could capture lessons learnt and complete the rehabilitation work in a controlled way and with a satisfactory safety standard (research question 1–4). The implementation of lessons learnt in the Company's experience carriers and in a new project was also studied (research question 5). This part of the evaluation shows more mixed results.

We will here discuss the findings from the case study based on Nonaka's learning spiral, focusing on the communities of practice involved and the role of documentation. Geology, scaling and rock support expertise played a significant role in the accident investigation and in the development of solutions.

Members of the investigation team together with personnel from the construction company, scaling company and OD and OE geologists made up a community of practice in accordance with the principles of Nonaka (1994), and demonstrated the viability of this concept. The group fulfilled several of Nonaka's conditions for experience feedback and learning to take place in such groups including overlapping and complementary qualifications. They developed solutions to manage the important interface between design and construction in an efficient way.

The investigation team members of this group also helped in transferring the experience to the basis organisation and to new projects, but to a more limited extent. With one exception, the members of this community of practice were all hired or Contractor personnel, and their experienced followed them to new jobs, mainly in other companies, and to their respective basis organisation. The Company lacked good processes for securing experience transfer from hired technical personnel, and especially the OE, to the Company's organisational memory.

Other communities of practice also played a significant role in the process, including project and safety management. Project management expertise in the project was deeply involved in the development of solutions from the project, Contractor and OE. They formed a community of practice at the project site, but the overlap with the Company's basis organisation was limited. This hampered the transfer of lessons learnt to the Company's experience carriers for use in future projects.

The safety management community of practice was visible in the process of developing solutions, especially in relation to the permit-to-work system. Representation from the Company's basis organisation was strong, and the lessons learnt were later followed up and implemented in the experience carriers for the safety management discipline. The safety management community of practice was instrumental in transferring experience to the Norwegian wind project.

The case study highlights the important role of the communities-of-practice within a cluster of companies involved in a rehabilitation project to capture experience and knowledge gained in the project. The size of each community within the individual company and the members' overlap with the basis organisation will have significant impact on the company's ability to capture experience (Kjellén 2004). Similarly, own employees in project management positions will likely be more motivated to contribute to experience transfer to the basis organisation and future projects than hired personnel in these positions.

Written documentation plays an important role as output from each turn of Nonaka's learning spiral. The project documented the results of its follow-up of the investigation in procedures and flow-charts for the work processes in moving forward in the canyon, the PTW system, and the method statements for scaling and rock support work. Although the accident received significant attention in the company, the documentation was only to a limited extent decontextualized and implemented into experience carriers by the Company's basis organisation. Several conditions in the Company and its environment may explain this fact. The Company's project and construction organisation has undergone major reorganisation in a period after the accident due to significantly changed market conditions for power investment projects. This resulted in lay-offs and changes that drew the attention away from the development of the governing system. Personnel in the communities of practice involved in the follow-up of the accident and with a stake in the basis organisation were, with some exceptions, too few and too strained to accomplish an adequate experience transfer.

A possible further explanation to the limited experience transfer is a lack of a suitable document structure in the Company to capture the experiences from the project's management of the interfaces between the different parties in the canyon road work. The developed solution involved the management by the project of complex interfaces between design, execution and technical follow-up, and required close coordination of several parties working under different contracts. Experience shows that it is easier to motivate company project personnel to update specifications to be used in contracts than to document own work processes for use in new projects (Kjellén 2004).

The idealized process for planning and execution of high-risk construction activities according to Figure 2 was originally developed to reflect the requirements to documentation in the different phases of a new project. The canyon road project followed a similar approach in developing the philosophy for moving forward in the canyon after the accident, and the approach produced good safety results. In the first step, detailed geological mapping and redesign of the road including support measures were carried out. Based on this documentation, the road construction contractor developed a project specific risk assessment and method statement for scaling work. In the last step, a detailed job safety analysis and method statement was developed for each section of the road and used in pre-job planning and briefing of the crew.

Quality assurance of the road contractor's scaling and rock support work played a central role in the implementation of the new strategy. The main tool for this was the PTW form, which served as a control sheet for documentation, implementation and verification of the safety standard of the work.

An important part of the new strategy was to break down the total scope of road rehabilitation into manageable sections, which were subject to detailed planning and job safety analysis and quality assurance through the PTW system. All these different measures involved increased bureaucracy and requirements to follow standardised and documented method of work, contradicting the aversion towards rules and procedures in the construction industry as mentioned in the literature review in the Introduction. This issue may also explain the reluctance in fully implementing the systematic approach in the Company's wind project in Norway, where the workers at the sharp end are more autonomous than in the Albanian project. This condition may also involve an increased risk of severe accidents.

Seen from a bird's eyes view, a significant learning from the accident investigation that falls outside the scope of this paper has been the importance of the constructability analysis that shall be carried out in the feasibility study phase. Such an analysis, if executed correctly, would have highlighted the needs of looking at alternative solutions to the rehabilitation and widening of the road such as construction of a new road in a tunnel parallel to the existing road.

7 CONCLUSIONS

The case study documents an example of a successful intervention to manage hazardous work in a road rehabilitation project. The intervention was triggered by a severe accident and the case demonstrates that the project had the ability to capture lessons learnt and complete the rehabilitation work in a safe and controlled way. An analysis showed that the basic elements of Nonaka's (1994) learning spiral were applied by the different organisations involved in developing and implementing solutions.

The ability of the Client Company to capture the knowledge for transfer to new projects was also analysed. The results were more uneven, which may be explained by different constraints. These included limited overlap between the project and the basis organisation in the company and a document structure representing the company's experience carrier to future projects that was not fully suited to capture the complex interfaces that were managed through the solution.

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Road safety culture among HGV drivers in Norway and Greece: Why do Greek HGV drivers commit more aggressive violations in traffic?

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ABSTRACT: The aim of the present study is to compare road safety behaviours among Greek and Norwegian HGV drivers, and to discuss these results in light of national road safety culture and other explanatory variables (e.g. age, sector, pay). We have conducted surveys among HGV drivers in Norway (N = 108) and Greece (N = 100). Results indicate that Greek HGV drivers report of more aggressive violations in traffic. National transport safety culture is measured as a "violations/aggression factor", where national culture is specified as descriptive norms, i.e. what respondents think that other road users in their countries do. This is the strongest contributor to aggressive violations in the analyses. Drivers' experience of customer pressure is also associated with drivers' aggressive violations. Finally, results indicate that a good safety culture is important for traffic safety, as it may reduce the impact of negative aspects of national culture and customer pressure.

1 INTRODUCTION

1.1 *Background*

Recent data shows that 1.24 million people die each year on the world's roads and between 20 and 50 million people sustain non-fatal injures (WHO, 2013). Thanks to traditional safety strategies targeting safety behaviours, technology and infrastructure, the number of fatalities has steadily decreased (Elvik et al, 2009), but there is still considerable room for safety improvement. One important accident risk factor not currently addressed by traditional transport safety interventions is poor safety culture (Ward et al, 2010; Nævestad & Bjørnskau, 2012).

The concept of (organizational) safety culture is usually traced to the 1986 Chernobyl disaster, which led to a shift of focus in the investigations and studies of safety in organizations. Several major accident investigations subsequently identified safety culture as a major contributing factor (Cullen, 1990; NASA, 2003; National Commission on the BP Deepwater Horizon Oil spill and Offshore Drilling, 2011). Organizational safety culture can be defined as "safety relevant aspects of culture in organizations" (Hale, 2000; Antonsen, 2009; Nævestad, 2010a). It is widely recognized that safety culture is important for safety in organizational settings in hazardous industries (Nævestad, 2010a).

The safety culture concept is applied to an ever-increasing range of sectors and industries, including professional and private transport (Wills et al, 2005; Davey et al, 2006; AAA, 2007; Girasek, 2012; Nævestad, Elvebakk & Bjørnskau, 2014). Recent research suggests that safety culture explains considerable variation in safety behaviour in various transport forms operated by both private and professional drivers (Nævestad & Bjørnskau, 2012; Nævestad et al, 2017). This research also suggests that if we are to fully understand its effects on safety in transport, we should study not only safety culture in organisations, but that particular to other social units, like peer-groups, sectors, regions and nations. Since safety culture is by definition shared, it must be related to social units. We define transport safety culture (TSC) as shared norms prescribing certain transport safety behaviours, shared expectations regarding the behaviours of others and shared values signifying what's important (e.g. safety, mobility, respect, politeness) (Nævestad & Bjørnskau, 2012).

A recent study comparing Norwegian and Greek bus drivers found that bus drivers in Greece report of more aggressive violations in traffic than Norwegian bus drivers, and that respondents' aggressive violations in traffic predicted their accident involvement (Nævestad et al, 2017). This study also found that aggressive violations were predicted by national transport safety culture, measured as shared expectation to other road users and values. Thus, this previous study indicates a relationship between national transport safety culture, transport safety behaviour and accident involvement, that perhaps could be developed further to shed light on national transport safety records. It follows from our definition of TSC, that it influences road safety behaviours, which in turn is related to drivers' accident involvement (Winter & Dodou, 2002). Thus, we may expect that differences in national road safety cultures could contribute to explaining differences in HGV accident risk in different European countries (DaCoTa, 2010).

1.2 *Aims*

The aim of the present study is to compare road safety behaviours among Greek and Norwegian Heavy Good Vehicle (HGV) drivers, and to discuss these results in light of national road safety culture and other explanatory variables (e.g. age, sector, pay). The study builds on, and uses the same survey items with the mentioned study of bus drivers in Norway and Greece (Nævestad et al, 2017). Thus, the present study compares results with this previous study, to evaluate whether results in the latter really indicate differences in national transport safety culture, or merely sectorial challenges (i.e. aggressive road safety behaviour) related to bus transport in Greece.

1.3 *The safe culture project*

The present study is part of a project titled "Safety culture in private and professional transport: examining its influence on behaviours and implications for interventions" funded by the Norwegian Research Council, and undertaken by the Institute of Transport Economics—TØI (Norway) and the National Technical University of Athens—NTUA (Greece). The project explores safety culture in land and sea based, professional and private transport in Norway and Greece. The main aims of the project are to examine safety culture and behaviour in road and sea transport, and to clarify implications for safety intervention strategies.

Norway and Greece were selected to be compared since the road safety status in the two countries differ significantly. The road fatality rate of Norway is one of the lowest in the EU (around 29 fatalities per million population in 2014). Its development was similar to the EU average in the period 2001–2014. (European Commission, 2016a). On the other hand, Greece has one of the worst transport safety records of all EU-27 countries (Yannis & Papadimitriou, 2012).

1.4 *Previous research*

1.4.1 *National differences in road safety behaviours*

Previous Research (Warner et al, 2011; Özkan et al 2006), especially using Driving Behaviour Questionnaire (DBQ) items, shows that when Southern Europe (Greece) and Northern Europe is compared, there are more aggressive violations in Greece. Research also indicates a relationship between drivers' accident involvement and their self-reported driver behaviours as measured by the DBQ items (Warner et al, 2011). Warner et al (2011) compare DBQ items between Finnish, Swedish, Greek and Turkish drivers. The drivers also reported their accident involvement during the previous 3 years. The results showed that nine key items (which drivers from different countries rated differently) could be identified. Out of these nine items, five items could explain differences in drivers' self-reported yearly accident involvement when all four countries were taken together. These five items were: 1) "Become angered by a certain type of driver and indicate your hostility by whatever means you can", 2) "Disregard the speed limit on a motorway", 3) Overtake a slow driver on the inside, 4) "Pull out of a junction so far that the driver with right of way has to stop and let you out" and 5) "Get into the wrong lane approaching a roundabout or a junction". One of the studied items: "Overtake a slow driver on the inside) explained differences in self-reported yearly accident involvement in Greece only.

And as noted, Nævestad et al (2017) found in a study of 228 bus drivers that bus drivers in Greece report of more aggressive violations in traffic than Norwegian bus drivers, and that aggressive violations were predicted by national transport safety culture, specified as descriptive norms ("violations") and values (individual freedom to take risk in traffic). Respondents' aggressive violations in traffic predicted their accident involvement, although "work related variables" were more strongly correlated.

1.4.2 *National safety culture*

Even though the concept traditionally has been applied to organizations, research indicates that safety culture can be applied to other social units than organizations. It can for instance be applied to studying the (traffic) safety culture of members of social units like nations, communities and peer groups (Nævestad & Bjørnskau, 2012; Nævestad, Elvebakk & Bjørnskau, 2014). The research literature on national culture shows that it influences values, communication styles, methods of conflict resolution, decision making and organizational behaviour. This is indicated in studies in aviation

(Merrit, 2000) and shipping (e.g. Håvold, 2005). It is reasonable to expect that, national traffic safety cultures are influenced by traffic rules, the police enforcing the rules, road user interaction, driver licensing and driver education (Nævestad & Bjørnskau, 2012). Leviäkangas (1998) has pointed to national culture comparing Russian and Finnish drivers. Comparisons of national traffic safety culture have also been made in the large EU-funded research project "SARTRE", which reported national differences among European car drivers' attitudes towards road safety (SARTRE, 1994; 1998; 2004; 2012).

1.4.3 *National culture as descriptive norms*

One way of facilitating such an analytical separation between culture and behaviour is to operationalize culture, or "expected national transport safety behaviours" as descriptive norms (Cialdini et al 1990). In previous research on traffic safety culture among bicyclists, such descriptive norms of respondents' peer groups were found to predict respondents' own traffic safety behaviours, which in turn predicted their accident risk (Nævestad, et al 2014). Individuals' perceptions of peers' opinions about a given behaviour are often defined as injunctive norms, while individuals' perceptions of what peers actually do often are defined as descriptive norms (Ajzen, 1991; Rivis & Sheeran, 2003; Ward et al 2010). Since injunctive norms are normative they can be expected to directly influence peoples' behavior. Descriptive norms may influence behaviour by providing information about what is normal (Cialdini et al., 1990). Such normative pressures on behaviour have been found in several studies of traffic safety behaviours (Nævestad et al 2014). Descriptive norms, can however also influence behaviour through the false consensus bias, in which individuals overestimate the prevalence of risky behaviour among their peers to justify their own behavior (Nævestad et al 2014).

1.4.4 *Other variables influencing behavior*

To sum up, the research on national road safety culture which has been done, uses different approaches, and it is difficult to find an approach which separates analytically between road safety behaviours and road safety culture. We think, however that it is important to separate between the two, as behaviours are influenced by far more variables than just culture (e.g. age, experience, sex). In current transport safety research, it is well established that key variables related to driver characteristics (age, sex, experience) explain a certain amount of variation in transport operators' safety behaviours (Elvik et al, 2009).

Additionally, studies of HGV drivers also find that work related variables influence their behaviours. Respondents in this sample are professional drivers. It is known from previous research that customer pressure (Nævestad & Bjørnskau, 2014), driver stress and time pressure (Nævestad et al, 2015), wage arrangements, e.g. commission pay (Steen Jensen et al, 2014) and management focusing on certain safety behaviours (Nævestad & Bjørnskau, 2014) also influence safety behaviour. Additionally, transport (sub)sector has been found to influence safety behaviors and accident risk, as transport of dangerous good have a 75% lower accident risk than other HGV transport (Elvik et al, 2009).

2 METHODS

2.1 *Surveys*

2.1.1 *Recruitment of respondents and sample*

Two surveys among professional HGV drivers from seven companies in Norway (and a group of drivers from unknown companies) and two companies in Greece were undertaken (total N = 208). To have comparable companies in the two countries, the recruitment of companies was based on the following criteria: 1) The vast majority (i.e. minimum 90%) of HGV drivers in each company should be of the main nationality (Norwegian or Greek), 2) Recruited drivers should include a mixture of drivers involved in long distance transport and distribution transport. In addition, a share of the Norwegian drivers was involved in transport of dangerous goods. We initially planned to recruit a similar group in Greece, but this was not possible. Nevertheless, the dangerous goods drivers are included to assess the importance of a sub sector which is known to have a high safety level in within HGV transport.

2.1.2 *Survey themes*

Working conditions with safety implications: Five questions based on previous work (Nævestad and Bjørnskau, 2014; Steen Jensen et al, 2014) were included. *Organizational safety culture*: An organisational culture index, consisting of 10 questions from the GAIN-scale on organisational safety culture was used (GAIN, 2001). The GAIN scale has been used in previous research from different transport sectors (Bjørnskau & Longva, 2009; Nævestad & Bjørnskau, 2014). The GAIN-scale originally consists of 25 questions measuring five themes, but the scale was reduced to 10 questions to facilitate the inclusion of other questions, measuring other topics. The questions were selected based on the following criteria: a) at least one question from each theme in the index, b) choose questions focusing on concrete/specific things (e.g. what a manager does), i.e. not general questions (e.g. manager commitment). *Safety behaviours*: Seven questions including questions taken from the DBQ and based on the results of previous research (Warner et al, 2011). The chosen DBQ questions were those who Scandinavian and Southern European drivers scored significantly different on, and which were related to accident involvement (Warner et al 2011). The DBQ answer alternatives have been changed from relative to absolute alternatives (e.g. Question: "For every ten trips, how often do you …?", Alternative answers: "Never", "Once or twice", "Three or four times", "Five or six times", "Seven or eight times", "More than eight times but not always", "Always"). The reason is that previous research shows that different demographic groups tend to interpret questions and formulations differently (i.e. what does "often" mean?) This effect has been found in surveys comparing the culture and behaviours of different national groups, e.g. HGV drivers from Norway and Central & Eastern Europe (Nævestad et al, 2016).

National transport safety culture index (Paternalism index, Trust in authorities, Expectations to other road users): The survey includes 9 questions on expectations to other road users, reflecting those used for respondents' own behaviour.

Sector transport safety culture: Six questions were constructed for this survey, but they are influenced by previous research on framework conditions for transport safety in road, sea and air transport (e.g. Bjørnskau & Longva, 2009; Nævestad, Phillips & Elvebakk 2015). It is noted that questions "I don't expect safety improvements in my sector in the next 10 years" and "Society accepts the current level of accidents that we have in my sector" are difficult to be used for comparison. These questions assume a poor safety level.

Safety outcomes: 4 questions based on previous work on fatigue (Nævestad and Bjørnskau, 2014; Nordbakke, 2004), on safety assessment (Størkersen et al, 2011) and also newly developed questions. Accidents is the most important outcome measure.

2.2 *Analysis*

When comparing the mean scores of different groups, we use one-way Anova tests, which compare whether the mean scores are equal (the null hypothesis) or (significantly) different. We use Chi square tests to compare groups' scores on particular variables, if we, for instance, cannot compare means due to the variables' level of measurement. The chi square test tests whether the actual distribution of groups on a variable is statistically significant different from a coincidental distribution, or an independent normally distributed sample.

We use hierarchical, linear regression analyses, where independent variables are included in successive steps to examine respondents' scores on the aggressive violations index. The most basic independent variables are included first, e.g. age, sex, vessel type, position. Then the other independent variables are included. Of course, we cannot conclude about causality, as this is a cross-sectional and correlational study. We nevertheless use the term predict when we describe the regression analyses.

3 RESULTS

3.1 *Survey*

3.1.1 *Description of the sample*

In Tables 1 to 3 the main characteristics of the survey sample are presented. The majority of drivers in the survey were aged between 36 and 55 years old. However, the share of drivers between 26–35 years old was over twice as high in Norway as in Greece, while there were more Greek drivers aged 46–55 years (Table 1).

In total, most of the survey participants are usually driving long distance, followed by a combination of long distance and distribution. In the Norwegian sample, 37% of the respondents drive dangerous goods (Table 2).

The majority of the drivers have a professional experience of more than 16 years, although the Greek drivers have higher shares in the two groups with the longest experience (Table 3).

Table 1. Distribution of professional HGV drivers per nationality and age.

	Driver's age					
Nationality	<26	26–35	36–45	46–55	56+	Total
Norwegian	3%	25%	31%	34%	8%	101
Greek	0%	12%	31%	48%	9%	100
Foreign in Norway	14%	0%	43%	43%	0%	7
Total	2%	18%	31%	41%	8%	208

Table 2. Type of transport.

	Type of transport				
Nationality	Long distance	Distribution	Long dist. & Dis.	Dang. goods	Total
Norwegian	17%	12%	35%	37%	101
Greek	52%	24%	24%	0%	100
Foreign in Norway	14%	29%	29%	29%	7
Total	34%	18%	29%	19%	208

Table 3. HGV drivers' years of working experience.

Nationality	Years of experience 0–5	6–10	11–15	16–20	20+	Total
Norwegian	8%	20%	23%	17%	33%	101
Greek	6%	11%	19%	25%	39%	100
Foreign in Norway	0%	43%	0%	14%	43%	7
Total	7%	16%	20%	21%	36%	208

The mean number or thousand km driven during the last two years by professional Greek HGV drivers is 155 000 km in the two last years. The corresponding number for Norwegian drivers was 154 000. While 34% of the Greek HGV drivers reported that they own their own vehicle, only 3% of the Norwegian drivers reported so. Accordingly, 27% of the Greek drivers reported to be self-employed, while only 3% of the Norwegian were self-employed. 92% of the Norwegian drivers held a permanent position, while 68% of the Greek drivers did.

3.2 *Factor analysis of the transport behaviour scale*

A confirmatory factor analysis (CFA) was conducted in order to examine the underlying factor structure of the items measuring transport safety behaviours. The items are based on the study of Warner et al (2011), who compare DBQ items in Finland, Sweden, Turkey and Greece. Their DBQ items which were either rated significantly differently and with eta values higher than 0,10 (= *), or which were rated significantly differently, and with eta values higher than 0,10 and which explain accident involvement (= **) were included in the analysis.

Based on this previous research by Warner et al (2011), and our own study of Norwegian and Greek bus drivers (Nævestad et al, 2017), it was assumed that a two-factor solution was appropriate (aggressive violations and speeding). The tests indicated that the items and the data were suitable for factor analysis. Bartlett's test of sphericity (approx. Chi-square) was 267,678 ($p < .001$). The Kaiser–Meyer–Olkin's measure of sampling adequacy showed a value of 0,646. The two first components had an Eigenvalue higher than 1, which explained a total of 72% of the variance. The scree plot also suggested a two factor solution. We used a principal component analysis (PCA) with Oblimin rotation, where we set the number of factors to two and the cutoff values of the factor loadings at 0,3 (cf. Table 4).

Table 4. Factor analysis results—transport behaviour scale.

Item	Aggressive violations	Over speeding
Sound your horn to indicate your annoyance to another road user	0,912*	
Become angered by a certain type of driver and indicate your hostility by whatever means you can	0,866**	
Pull out of a junction so far that the driver with right of way has to stop and let you out	0,456**	
Disregard the speed limit on a residential road		–0,905**
Disregard the speed limit on a motor way road		–0,880**

3.3 *Factor analysis of the national culture scale*

An exploratory factor analysis (EFA) was conducted in order to examine the underlying factor structure of the items measuring national transport safety culture. The tests indicated that the items and the data were suitable for factor analysis. Bartlett's test of sphericity (approx. Chi-square) was 872.280 ($p < .001$). The Kaiser–Meyer–Olkin's measure of sampling adequacy showed a value of 0,806. The Eigenvalues and the scree plot indicated a two-factor solution. The two first components had an Eigenvalue higher than 1, which explained a total of 65% of the variance. We used a principal component analysis (PCA) with Oblimin rotation, where we set the number of factors to two and the cutoff values of the factor loadings at 0,3. This produced the following result.

3.4 *Regression analyses*

In Table 10 we show results from a hierarchical, linear regression analysis, where independent variables are included in successive steps to examine the variables predicting respondents' transport behaviours (aggressive violations). The table presents the standardized beta coefficients. The contributions of the different independent variables on the dependent variables can therefore be compared directly. The 30 self-employed drivers were excluded from these analyses, as the analyses also include variables measuring management support and organizational safety culture (which also largely focuses on management support). The self-employed drivers were excluded from the analyses, as they are "their own managers". The scores on the dependent variable vary between 3 and 21.

Table 5. Aggressive violations index.

Nationality	Mean	N	Std.D
Norwegian (not danger. goods)	4.7	66	2.00
Norwegian (dangerous goods)	4.6	36	2.03
Greek	5.8	100	3.12
Foreign in Norway	4.6	7	2.30
Total	5.2	208	2.66
P = 0.01			

Table 6. Over speeding index.

Nationality	Mean	N	Std.D
Norwegian (not danger. goods)	5.2	65	4.09
Norwegian (dangerous goods)	4.2	36	4.01
Greek	4.8	100	3.98
Foreign in Norway	2.7	7	1.50
Total	4.7	208	3.98
P = 0.4			

Table 7. Factor analysis results—national culture scale.

Item	Aggression/ Violations	Compliance/ Politness
That they sound their horn to indicate their annoyance to another road user	0,812	
That they become angered by a certain type of driver and indicate their hostility by whatever means they can	0,790	
That they overtake a slow driver on the inside	0,786	
That they drive when they suspect they might be over the legal blood alcohol limit	0,771	
That they disregard the speed limit on a motor way road	0,728	
That they drive without using a seatbelt	0,720	
That they disregard the speed limit on a residential road	0,717	
That they respect and follow traffic rules		0,907
That they are polite to other road users		0,879

Table 8. National culture: Violations (min 7, max 49).

Nationality	Mean	N	Std.D
Norwegian (not dang. goods)	15.5	65	4.99
Norwegian (dangerous goods)	15.4	36	4.33
Greek	17.9	100	6.6
Foreign in Norway	15	7	4.4
Total	16.6	208	5.8
P = 0,000			

Table 9. National culture: Politeness (min 2, max 14).

Nationality	Mean	N	Std.D.
Norwegian (not dang. goods)	6.5	65	2.3
Norwegian (dangerous goods)	7.1	36	2.46
Greek	4.6	100	2.10
Foreign in Norway	5.7	7	2.29
Total	5.7	208	2.46
P = 0,305			

Table 10. Linear regression. Dependent variable: "Aggressive violations" Standardized beta coefficients.

Variables	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Age group	.012	.016	–.036	–.034	–.028	–.003
Dangerous goods		.057	.056	.056	.057	**.135***
Customer pressure			**.252*****	**.249*****	**.232*****	**.156****
Comm. pay				.089	.097	.096
Org. safety culture					**–.196*****	**–.197****
Nat. culture						**.304*****
Adj. R2	–.006	–.008	.048	.051	.084	.162

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

We see that drivers' age does not contribute significantly to aggressive violations. Dangerous goods, i.e. sector, contributes significantly at the 10% level when national TSC is included in the analysis. The type of transport variable was dichotomized when we saw that the mean score on the aggressive violations index was lower for dangerous goods drivers. Neither does commission pay contribute significantly. This variable was dichotomized when we saw that the mean score on the aggressive violations index was higher for drivers working only for commission pay.

We also see that the variable "In my job, I experience that customers put pressure on/cause stress for drivers" contributes significantly at the 5% level. This indicates that stressed drivers, act more aggressive in traffic, also when we control for national culture, i.e. the general level of aggression in the driving population.

National transport safety culture is measured as a “violations/aggression factor”, where national culture is specified as descriptive norms, i.e. what respondents think that other road users in their countries do. This is the strongest contributor to aggressive violations in the analyses.

It is important to note that organizational safety culture contributes negatively to aggressive violations, indicating that a good safety culture is important for traffic safety, and that it may reduce the impact of national culture.

The adjusted R^2 value increases from 0,084 in Step 5 to 0,162 in Step 6, when national culture is included in the analysis. This demonstrates the high importance of national culture as a predictor of aggressive violations. Finally, the adjusted R^2 value is of .162 indicates that the model explains 16% of the variation in the aggressive violations variables.

4 DISCUSSION

As the rate of improvement in transport safety has slowed down in recent years, it has been suggested that new perspectives are needed to complement the traditional perspectives on transport safety. The present paper contributes to this by showing how the transport safety behaviours of Norwegian and Greek HGV drivers are influenced by their respective national transport safety cultures. Our main finding that Greek HGV drivers commit more aggressive violations than Norwegian HGV drivers is in accordance with previous research on private road users in Scandinavia and Southern Europe (Wallen et al 2011). Nævestad et al (2017) found the same results, using the same items, studying bus drivers in the two countries.

Transport safety culture is defined as shared norms prescribing certain transport safety behaviours, shared expectations regarding the behaviours of others and shared values signifying what’s important. In this study, we only focus on one aspect of TSC, i.e. the shared expectations regarding the behaviours of others. National transport culture is measured by means of a “violations factor”, specified as descriptive norms (Cialdini et al 1990), i.e. what respondents think that other road users in their countries do. This is the strongest contributor to respondents own aggressive violations in traffic. Previous research has also found that descriptive norms predict transport safety behaviours (Nævestad et al, 2014).

Nævestad et al’s (2017) study of bus drivers also found that bus drivers’ traffic safety behaviours in Norway and Greece can be explained in light of their TSC. However, their study also specified national transport safety culture by means of an “individual freedom” factor, made up of three items reflecting the value of individual freedom to take risk in traffic. This factor was also found to influence bus drivers’ aggressive violations. We have unfortunately not been able to also examine these aspects of culture in the present study. Thus, our conceptualization of national TSC can be criticized for not being comprehensive enough. Shared expectations regarding the behaviours of others is, however, a key component in our definition of transport safety culture.

It could also be argued that the effect of national culture, specified as violations, could be interpreted as a result of the false consensus effect, meaning that people think that other people do as they do, to justify their own behaviour. The Norwegian dangerous goods drivers may provide a test of this hypothesis, as they are less likely to over speed (1 point less) compare to the other Norwegian drivers, and slightly (.2 points) less aggressive. The national culture “violations index” include the same questions on speeding (and aggression) as the behaviour index. Nevertheless, we see that the scores of the Norwegian drivers who drive dangerous goods and those who do not are almost identical (15.4 and 15.5). Thus, it seems that the national culture differences cannot be explained as a false consensus effect. On the other hand, it seems that the differences are due to expectations based on the drivers’ experiences on the road of their respective countries.

The previous studies that have used the DBQ items to do cross-cultural research found relationships between safety behaviours and accident involvement (Warner et al, 2011). Nævestad et al’s (2017) study of bus drivers also found that respondents’ aggressive violations in traffic predicted their accident involvement, although “work related variables” were more strongly correlated. We have unfortunately not been able to include analyses focusing on the relationship between aggressive violations and accident involvement here, but previous relationship indicates that there is such a relationship, signifying the importance of our study.

Our study also indicates that pressure and stress from customers are associated with HGV drivers’ tendency to commit aggressive violations, controlled for national TSC. The negative effect of customer pressure on driver behaviour has also been highlighted in previous research. HGV drivers triggering fatal accidents are more stressed (Nævestad et al, 2015). A literature review indicates that organization of transport, e.g. preventing direct contact between drivers and customers, may reduce the effect of this (Nævestad et al., in review).

Our analyses included variables on sub-sector (Elvik et al, 2009), age (Elvik et al, 2009), commission pay (Steen Jensen et al, 2014), as these variables have been found to influence professional driver behaviour. The fact that they did not, could be due to little internal variation in our sample. The dangerous goods drivers are for instance only in the Norwegian sample. Additionally, there are few drivers with a pure commission pay in our sample. The age variable is distributed more evenly, and the result that it does not contribute significantly seem to indicate that other variables are more important, e.g. national culture and work pressure. More research is needed with larger and more heterogeneous samples.

A final main result of the present study is that we found that organizational safety culture contributes negatively to aggressive transport safety behaviours, meaning that a positive organizational safety culture may reduce the (negative) impact of national transport safety culture and customer pressure on aggressive violations in traffic.

5 CONCLUSION

The main contribution of the present paper is that it associates traffic safety behaviours with national transport safety culture, thereby providing a new way of understanding and intervening to improve traffic safety. The study indicates that group membership is important for safety behaviour, both positively and negatively. Future research should therefore examine further how it is possible to draw on this knowledge to improve road safety. A key question is e.g. whether it is possible to socially influence private road users, who are not members of organizations, through other social units (e.g. peer groups, communities).

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Improving occupational safety in in-house logistics with the aid of digital measures

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ABSTRACT: Logistics involve the risk of occupational accidents. Occupational accidents in in-house logistics have often been studied from the accident prevention perspective. Even though warehouse work involves new technology, the effect of these new technologies on occupational safety has not yet been widely studied. The objective of our study is to determine whether digital feedback and learning systems can improve safety of forklift drivers. Their attitude reflects their ability and willingness to adopt new technology, and the purpose of this paper is to present attitudes towards new technology.

Altogether, 216 forklift truck drivers completed the initial questionnaire. One third of these respondents had been involved in an occupational accident during the three preceding years. The attitude of the respondents towards digital systems was positive, as 78% considered that IT solutions increased the fluency of their work, and 61% believed that IT solutions improved occupational safety in their work.

1 INTRODUCTION

1.1 *Accidents in in-house logistics*

Logistics involve the risk of occupational accidents. In Finland, material transfers cause one quarter of all fatal occupational accidents (Perttula & Salminen 2012). Overall, occupational accidents related to material transfers also cause longer disabilities than other occupational accidents (Perttula et al. 2003). Material transfer-related accidents occur in in-house logistics, i.e. in warehouses and terminals (Perttula 2013), and in warehouses, occupational accidents often involve forklift trucks (de Koster et al. 2011). The factors behind occupational accidents include busy traffic flows, different forms of transfers using the same routes, and time pressure.

Occupational accidents in in-house logistics have often been studied from the accident prevention perspective. Studies promoting occupational safety in warehouses have highlighted some risk factors such as physical strain in both manual and mechanical material transfers (Denis et al. 2006; Lanoie & Trottier 1998), as well as risks caused by the transferred material itself (St-Vincent et al. 2005). The prevention of physical strain has been promoted by ergonomic studies (Roman-Liu 2010; Mack et al. 1995). In addition to the traditional background factors of occupational accidents, some studies in the warehouse sector have also focused on psychological and behavioral factors (Koster et al. 2011). However, even though warehouse work involves new technology, the effect of these new technologies on occupational safety and the fluency of work has not yet been widely studied.

Accidents in in-house logistics often involve forklifts (Koster et al. 2011). The factors behind these accidents are frequently a large amount of traffic in warehouses, different modes of moving in the same area and time pressure. Further challenges for forklifts arise from confined work environments. Drivers need to manage their work environment: to be aware of people moving in their work area and to control the movements of their vehicle (Saric et al. 2013). Other risk factors in the work environment involve lighting, routes (maintenance, markings, tidiness, visibility, etc.), physical load, and psychosocial factors. Another problem for forklift drivers is limited visibility, because the load is located in front of them, in their field of vision.

1.2 *Need for new technology for preventing accidents*

Although warehouse work has been a target for new technology, the effect of this technology on occupational safety and on the fluency of work has not been a central focus of recent studies. The follow-up and feedback system of driving habits, however, has been developed and studied in road traffic (Innamaa & Penttinen, 2014), but the focus has been more on economical driving rather than safety. Drivers' acceleration and speed have been found to successfully predict accident tendency (Wåhlberg 2007; Sagberg et al. 2015). Our study concentrates on utilizing new technology in in-house logistics, which still involves a high risk of accidents regardless of traditional preventive actions. We use existing technology to promote occupational safety in cooperation with in-house logistic companies.

In addition to utilizing existing technology, this study project focuses on developing learning through games. The purpose of learning games is to promote forklift drivers' ability to recognize and predict hazards while driving. Many forklift drivers' accidents involve excessive speed because of time pressure (Saric et al. 2013), which also reduces their ability to recognize risks in their work environment.

1.3 *Purpose of the paper*

For forklift drivers to successfully manage new technology, information regarding their attitude towards new IT solutions is necessary. Their attitude reflects their ability and willingness to adopt new technology, and the purpose of this paper is to present a basis for our study project, i.e. attitudes towards new technology.

2 MATERIALS AND METHODS

2.1 *The study project*

The study project is an intervention study, and we use a before-after frame to assess the possibilities that digital feedback and learning systems present for safety. The study material will be gathered from four companies in Finland during 2016–2019, using methods of document analysis, questionnaires and interviews. The two interventions are scheduled in a way that enables us to assess the effect of both. We will also conduct interviews to determine other changes and factors that influence safety. Safety level will be assessed using questionnaires at the beginning and the end of the study.

The objective of our study is to determine whether digital feedback and learning systems can improve safety. Our study is an intervention study, and we use a before-after frame to assess the possibilities that digital feedback and learning systems present for safety. The study material will be gathered from four companies during 2016–2019, using methods of document analysis, questionnaires and interviews. The two interventions are scheduled in a way that enables us to assess the effects of both. We will also conduct interviews to determine other changes and factors that influence safety. Safety level will be assessed using questionnaires at the beginning and the end of the study.

The study questions are:

1. What is the effect of digital feedback technology on occupational safety measures?
2. Can videogames increase the ability to predict hazards in forklift drivers' work?
3. What are forklift drivers' attitudes towards the use of new technology?

The study project consists of five different phases:

1. Present state analysis (document analysis, survey, interviews)
2. Intervention 1: Implementation of an in-house logistics digital feedback system
3. Intervention 2: Video-based learning game
4. Mid-term evaluation
5. Final state analysis (document analysis, survey, interviews).

2.2 *Survey*

This paper focuses on Study question 3 and the material was gathered during Phase 1 of the study project, which included a survey of workers and semi-structured interviews in the participating companies. The survey consisted of the following sections:

A. Background information
B. Flow of and disruptions in work
C. Safety at work
D. Safety climate at the workplace
E. Experiences of IT solutions.

Background questions elicited the respondents' age, educational background, managerial tasks, work experience and hours of overtime. This paper focuses on one part of survey Section E in particular: the statement, "IT solutions make your work safer". The respondents rated this statement on a four-point Likert scale (completely agree, partly agree, partly disagree, completely disagree). The answers were grouped in to agree and disagree during the analysis phase.

2.3 *Participants*

The survey questionnaire was sent to 772 workers, and was completed by 404. The response rate was thus 52%. Of the respondents, 216 drove forklift trucks during their working days, the others worked in offices or in production.

Semi-structured interviews were conducted with 33 individuals: 9 top managers, 11 mid-level managers and 13 workers. They were all asked their opinion on the possibilities that digitalization presented for improving occupational safety.

2.4 *Analysis*

Two non-parametric independent sample tests were performed to assess the differences between the respondents who completely or partly agreed with the statement "IT solutions make your work safer" and those who partly or completely disagreed. Statistical analysis was performed using SPSS, version 24.

3 RESULTS

3.1 *Occupational accidents*

Of the entire participant group, 23% reported having been involved in a workplace accident during the three preceding years. When the responses were limited to only the forklift driver group, one third (33%) reported having been involved in occupational accidents during the three preceding years.

3.2 *General attitude towards IT solutions*

The general attitude of the respondents towards IT solutions was positive. Table 1 presents these responses. The respondents agreed with most of the 10 statements. Only three of the 10 statements received more disagreement responses, and these three questions included negative statements: you are worried that IT solutions enable your employer to find out information about you that you are not willing to give; sometimes you feel that IT devices and systems were not designed to be used by regular individuals; and IT solutions always let you down when it matters.

Table 1. Experiences of IT solutions, N = 404.

Statement	Disagree [%]	Agree [%]
IT solutions enhance the flow of your work	22	78
IT solutions make your work safer	40	61
IT solutions improve the quality of your work	30	70
IT solutions help you work more efficiently	33	67
You have received sufficient training at work to use the IT	38	62
You are worried that the IT solutions enable your employer to find out information about you that you are not willing to give	71	29
At your workplace, the most cutting edge vehicles/machines/devices are the most pleasant to use	33	67
You trust the vehicles/machines/ devices to work as intended	22	78
Sometimes, you feel that the IT devices and systems were not designed to be used by regular individuals	54	46
IT solutions always let you down when it matters	57	43

Most of the respondents agreed with the statements that IT solutions

- enhanced the flow of their work
- made their work safer
- improved the quality of their work.

The interviews also revealed positive attitudes towards IT solutions. All the participants answered that they saw positive possibilities for digitalization to improve occupational safety.

3.3 *Difference between forklift drivers and other respondents*

More than half (53%) of the respondents drove a forklift during their work shifts. A comparison of the answers of those who did not drive a forklift truck to those who did revealed some differences between attitudes to IT solutions.

The statistical differences between forklift-drivers and non-forklift drivers were limited to four statements. The respondents who do not drive forklift trucks agreed more strongly with these four statements:

- IT solutions make your work safer ($p < .05$)
- IT solutions improve the quality of your work ($p < .05$)
- IT solutions help you work more efficiently ($p < .05$)
- You have received sufficient training at work to use the IT solutions that you require ($p < .05$).

3.4 *Improved safety and fluency of work*

The background factors of the forklift drivers who felt that IT solutions made their work safer or more fluent did not differ statistically significantly, i.e. age, gender, education, whether they performed managerial tasks, work experience in present workplace, or hours of overtime. The forklift drivers' answers regarding being involved in occupational accidents or whether they found it difficult to report hazardous incidents did not differ either.

Table 2 shows the statistically significant differences between the forklift drivers who agreed with the statements that IT solutions make their work safer or more fluent and those who disagreed. All these statistically significant differences appeared among the drivers who agreed with the statements.

One statement did not receive statistically significant different responses among forklift drivers

Table 2. Statistically significant differences between drivers' responses of agreement and disagreement with the statement that IT solutions make their work safer (Safer) or IT solutions enhance the flow of their work (More fluent).

Statement	Safer	More fluent
IT solutions enhance the flow of your work	***	
IT solutions make your work safer		***
IT solutions improve the quality of your work	***	***
IT solutions help you work more efficiently	***	***
You have received sufficient training at work to use the IT solutions that you require	***	**
Sometimes, you feel that the IT devices and systems were not designed to be used by regular individuals.	*	*
IT solutions always let you down when it matters.	***	***
At your workplace, the most cutting edge vehicles/machines/devices are the most pleasant to use		**
You trust the vehicles/machines/devices to work as intended.		*

*$p < .05$; **$p < .01$; ***$p < .001$.

regarding either safer work or enhanced flow: You are worried that the IT solutions enable your employer to find out information about you that you are not willing to give.

4 DISCUSSION

Despite the major changes that work life is undergoing, in-house logistics still seems to be increasing. Although consumer habits are changing and digital shopping is increasing, the need for storage still exists. Warehouse and storage operations face functional changes but the need for forklift drivers will continue. Thus, the need to improve safety in in-house logistics will remain important in the future. Of our study participants, 33% of the forklift drivers reported having been involved in an occupational accident during the three preceding years. Our study of forklift drivers reflects results to those of previous research in the construction sector (Perttula et al. 2003): material transfer-related accidents are more severe than other occupational accidents. This indicates that all new ways of promoting the safety of forklift drivers are necessary.

Conducting intervention studies in safety research is challenging, as other simultaneous changes at workplaces can also affect safety in an unpredictable way. Our study project determines whether occupational safety can be improved by digital feedback and learning solutions. Thus, it is important to understand that, in addition to the digital systems themselves, the attitudes towards and the atmosphere created by technology also play a key role. According to Godoe & Johansen (2012), an individual who is optimistic about technology in general, considers a specific system more useful and easier to use than someone less optimistic. In our study project, it is vital to determine the attitude towards digital systems when conducting interventions.

Our survey shows that forklift truck drivers regard new technology and IT systems as positive for improving safety and work fluency. This means that the basis for the interventions is encouraging, and we assume that they will be accepted positively.

The focus of our study is forklift drivers. However, it has been interesting to see that the differences in attitudes towards new technology among forklift drivers and those who do not drive forklift trucks does not vary to any great extent. Forklift drivers' work mostly consists of tasks other than using IT solutions, and this makes the differences among two groups (forklift drivers and other workers) understandable. Our survey did not specify the IT solutions; the term was used in general. Although we can assume that office workers consider the term differently to forklift drivers, the attitude was still positive overall. The differences probably reflect different work tasks and different experiences of IT solutions at work.

As any measure for promoting workplace safety, taking into account new technology requires safety communication. The way in which the positive attitude of our respondents towards digital systems is utilized will depend on practical communication, management's visible commitment to safety, and mutual understanding of the usefulness of the interventions.

5 CONCLUSIONS

Forklift workers face safety risks during their work shifts. Our survey determines whether digital measures can help improve safety in in-house logistics. Its preliminary function however is to determine the attitudes towards IT systems and new technology. In four companies operating in in-house logistics, our survey showed that this attitude is positive, which is conducive for implementing our interventions. The more positive the respondents' attitude to IT systems' possibilities to improve safety, the more positive the attitude towards all new technologies.

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Chemical hazard risk in emergency services

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ABSTRACT: On daily basis, emergency medical service's staff (EMS) is exposed to different chemical hazardous products. The most common chemical hazards for EMS are related to vehicle fluids (during maintenance work as well as attending patients who have suffered a traffic accident), cleaning and disinfection products, compressed gas and drugs handling. The hazardous products are evaluated together with the PPE security data tables called global Harmonized System (GHS/SGA) and the laws related to them. The PPEs that are used are good enough in most cases; it is important to use them while checking and servicing the vehicle, working at traffic accident sites, cleaning and disinfecting the ambulance and instruments and when dangerous medication is being manipulated. Each EMS must check the PPEs they give their staff. Training and establishing safety protocols for the EMS workers in these situations is very important.

1 INTRODUCTION

1.1 *Chemical products*

Nowadays, the use of chemical products is common in all areas of activity, so there are safety and health risks in many workplace environments.

There are more than 130 million chemicals that are registered in the Chemical Abstract Service. Used in large quantities or in small doses, they are frequent in daily activity. Additionally, new products are introduced every year on the market.

The activity of health workers responsible for out-of-hospital care is not exempt from the use of chemicals, and therefore from exposure to certain hazards.

For those reasons, there is a need of awareness in terms of safety, in the use of chemicals at work. In order to implement effective control mechanisms of chemical hazards in the workplace, it is necessary full and up-to-date information on their hazards and the safety measures to be taken during their use and handling.

In addition to this flow of information, the incumbent companies must take actions to adopt and implement the necessary measures to protect workers, the population and the environment.

A healthy work environment is vital for a healthy working life. We must be aware that any work involves associated health risks, so we include in the term "Occupational Health" the physical, psychological and social balance of an individual in his work environment. Even more when this work environment is changing and variable as in the case at hand.

It is important to focus on the causes that cause those hazards to carry a certain risk.

We could summarize these causes as:

- Misinformation.
- Lack of awareness.
- Lack of training.
- Bad practices and overconfidence.
- Failure to comply with standards and resistance to acceptance.
- Inadequate or non-existent working procedures.

Prevention of occupational risks is the discipline that seeks to promote the safety and health of workers through the identification, evaluation and control of hazards and risks arising at work.

Hence, it is very important to promote activities and action plans to prevent those risks related to work activities where there is a high probability that something is happening. This communication is the result of the study conducted for a representative sample of chemicals used in the maintenance and cleaning of the mobile units, chemicals handled routinely during patient care (medication vials, oxygen, curative material, etc.)

and also other chemical products that we find daily in our interventions (as vehicle fluids after an accident). Concern is increasing on regards of the correct handling of different products, mixtures and compounds, and how they can impact on workers' health.

We have considered that chemical risks related to situations of chemical accidents are not within our study, since in those cases the emergency medical services (SEM) personnel stays in a safe area and the risk is valued by specialized professionals. Therefore, the scope of this study includes those usual cases in which non-specialist workers are the ones who must protect themselves. In the case of SAMUR-Protection Civil, note that all its workers have received basic training in chemical risk situations, and get regular updates periodically.

Therefore, it aims to:

- Promote a culture of prevention among administrations, employers and workers, promoting awareness of the existence of labor risk prevention regulations, meaning rights and obligations for all the incumbent ones.
- Promote safe behavior and prevention at workplaces, through awareness of individual protection.
- Improve the prevention of occupational hazards and working conditions and reduce potential accidents.
- Achieve the involvement of the whole organization in the preventive activity.

The proper utilization, storage and handling of chemicals used in cleaning and maintenance of vehicles and in health care is associated with a series of occupational hazards that can be avoided or minimized, which is the purpose of this communication.

Therefore, it becomes essential and crucial that the workers learn, through information and training, about the risks they are exposed as well as how to prevent and self-protect against them.

1.2 *Chemical risks*

From the prevention point of view, the employer has the responsibility to identify the chemical risks that are present at the workplace and to inform and train his employees about those the risks.

When analyzing the work of the SEMs (see Fig. 1), it is relevant the information corresponding to:

- Cleaning and disinfectant agents, detergents, etc.
- Drugs, including anaesthetic drugs, cytostatic/cytotoxic drugs, substances which can endanger the reproduction.

Figure 1. Daily work in an EMS.

- Compressed gases.
- Vehicle exhaust and liquids.
- Exposure to latex.

The latter has been solved by replacing the material with another. So we will focus on the rest.

2 EUROPEAN AND INTERNATIONAL REGULATIONS

REACH is the European Union Regulation adopted to improve the protection of human health and the environment against the risks brought by chemicals (as indicated on the website www.echa.europa.eu).

In 2006, the European Parliament approved Regulation (EC) No 1907/2006 delivered by the European Parliament and the Council on the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

The main highlights of the Regulation are related to:

- the obligation to register at the European Chemical Agency (ECHA) all new products, including those ones that are similar but made by different manufacturers.
- Facilitates the free shipment and commerce of those products properly registered and labeled across all the European countries.
- Mandates manufacturers to write safety data sheets in which hazardous products and components are incorporated, as well as personal protective equipment required to manipulate or handle them.

2.1 *US regulations*

In the United States there are several regulations on this subject. The most important is called Toxic Substances Control Act ("TSCA"), which provides the Environmental Protection Agency (EPA) with the authority to protect humans and environment, according to the National Electrical Manufacturers

Association (NEMA). In addition, proponents of this style of regulation indicate that European style affects free trade and they also estimate that 10% of products would have to be withdrawn from the market.

2.2 *International Labor Organization (ILO)*

In 1993, the ILO wrote a code of practice, which goal was: "The objective of this code is to protect workers from the hazards of chemicals, to prevent or reduce the incidence of chemically induced illnesses and injuries resulting from the use of chemicals at work, and consequently to enhance the protection of the general public and the environment".

This code applies to all industries and products that are in contact with chemicals. Although it was elaborated many years ago, the purpose and goal is still fully valid.

For many years, the ILO has tried to convince the international community about the importance of chemical control in taking measures to protect workers against chemical hazards.

The Convention Concerning Safety in the Use of Chemicals at Work was held in Geneva on 25 June 1990. It was driven by the ILO and the World Health Organization, counting on the support from the European Commission of the International Chemical Safety Cards database.

And in 2014, the ILO published a report about Safety and Health in the use of chemicals at work in which they answer the most frequent questions.

2.3 *Modifications in labeling and risk signs driven by REACH*

The use of chemical products is common both in the domestic environment and in the workplace, being used in many processes and jobs. The regulation established by the EU in 2009 introduces new rhomboid pictograms that inform us of the nature of the hazard of the product or mix of products that we are going to use.

The hazards have been grouped into three types, according to their effects.

These three sections are:

1. PHYSICAL HAZARDS.
2. HAZARDS FOR HUMAN HEALTH.
3. HAZARDS TO THE ENVIRONMENT.

Here bellow follows the hazardous definition related to a particular code, that is corresponding to a pictogram (see Figure 2):

- GHS1 – EX: This pictogram refers to explosive, self-reactive and organic peroxides that can cause an explosion if heated.

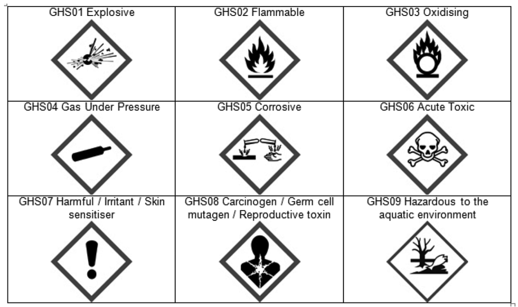

Figure 2. Hazard pictograms of chemical risks, according to the REACH.

- GHS2 – IN: Pictogram similar to GHS3. It warns of flammable gases, aerosols, liquids, and solids, such as:
  - Substances and mixtures of spontaneous heating
  - Pyrophoric liquids and solids that may ignite in contact with air
  - Substances and mixtures which emit flammable gases in contact with water
  - Self-reactive substances or organic peroxides that can cause fire if heated
- GHS3 – CB: If you find this pictogram on the label means that you are in the presence of gases, solids or oxidizing liquids that can cause or intensify a fire or explosion.
- GHS4 – GZ: Chemicals with this pictogram mean:
  - Gas under pressure, may explode when heated
  - Refrigerated gas, may cause ripening or cryogenic injury
  - Gases dissolved
  - Inert or safe gases are hazardous when packaged under pressure.
- GHS5 – CR: Whenever a chemical product is used with this pictogram, note that it is corrosive and that it can cause severe skin burns and ocular damage. It is also corrosive to metals.
- GHS6 – TO: This pictogram indicates that you are in the presence of a chemical that is extremely toxic in contact with the skin, if inhaled or ingested, and can be fatal.
- GHS7 – DA: This pictogram may refer to one or more of the following hazards:
  - High toxicity.
  - Causes skin sensitization, skin and eye irritation.
  - Irritant for breathing.
  - It is a narcotic, causes drowsiness or dizziness.
  - Hazardous to the ozone layer.
- GHS8 – MU: A substance or mixture bearing this pictogram may have one or more of the following effects:

- ○ It is carcinogenic.
- ○ It affects to fertility and to the unborn.
- ○ Causes mutations.
- ○ It is a respiratory sensitizer, which can cause allergies, asthma or breathing difficulties by inhalation.
- ○ It is toxic to certain organs.
- ○ Aspiration hazard, which can be fatal or very harmful if ingested or penetrated by any route into the body.
- GHS9 – EN: This pictogram warns that the substance is toxic or harmful to plants, aquatic organisms or the environment in general.

3 CHEMICAL RISK IN AN EMERGENCY MEDICAL SERVICE (EMS)

We will focus on the daily hazards that can affect workers regarding contact with chemicals, since it is considered that specialized personnel of the HAZMAT teams will be attend calls related to chemical spills, accidents of vehicles of hazardous materials or any other attack with chemical agents.

3.1 *Risks during the vehicle maintenance, and assistance on traffic accidents*

During vehicle inspection and maintenance tasks (see Figure 3), the assigned workers have contact with different car liquids, battery fluid, brake fluid, steering fluid, oil, diesel, etc. Similarly, workers who assist victims during a traffic accident also come into contact with them (see Figure 4).

After conducting a study of the safety data sheets of the most common products, it is concluded that most products present a risk of flammability, or are irritating products, and in some cases they are corrosive as the liquid of the batteries, as can be seen in Table 1.

The most dangerous fluid is the sulfuric acid, present in the vehicle's batteries. This product is corrosive and highly irritating by inhalation, so it is essential to use a filter mask in its presence. In the case of power steering fluid, the respiratory tract should be protected with a mask.

Figure 3. Mechanic maintenance works.

Figure 4. EMS working over a traffic accident.

Table 1. Chemical risks at vehicle fluids.

Product	Risk	Skin pr.	Eye pr.	Airway pr.
Freeze	Not evi.	Gloves	Glass	Not neces.
Brake fluid	Irritate	Gloves	Glass	Not neces.
Power steering f.	Inhal.	Gloves	Glass	Masque
Motor oil	Inflam.	Gloves	Glasss	Not neces.
Diesel	Inlflam	Gloves	Glass	Not neces.
Battery fluid	Corros.	Gloves	Glass	Masque

All other fluids present similar flammability hazards and the usual Personal Protective Equipment (PPE) to perform these tasks are:

- Safety glasses
- Protective gloves, with the usual nitrile gloves
- Skin protection by uniformity with long sleeve

3.2 *Risks during the cleaning and disinfection*

The cleaning and disinfection of vehicles and their equipment is another of the moments of greater chemical risk, since different products will be used to avoid both dirt and, more importantly, to avoid the transmission of nosocomial diseases, by crossover transmission to the other patients attended (see Figure 5).

Products specifically intended for the disinfection of medical devices must bear the CE marking on their label, accompanied by the identification number of the notified Organization that has been involved in their assessment.

The manufacturer must have made an EC Declaration of Compliancy with the requirements of the medical devices regulation, and must hold the corresponding CE certificates issued by a notified Organization (as indicated in Amy, G. 2000. Disinfectants and disinfectant by-products. Geneva, World Health Organization).

Figure 5. Cleaning and disinfecting ambulance interior.

The Spanish Agency for Medicines and Sanitary Products (according to the Guide of antiseptics and disinfectants of the Universitary hospital of Ceuta), classifies disinfectants into 3 legal categories:

- BIOCIDES: this includes antiseptics for healthy skin, including those intended for the pre-surgery field and those intended for the disinfection of the injection site, as well as de-sanitizers for environments and surfaces used in the clinical environments that do not come into direct contact with the patient, such as those intended for corridors, hospital areas, care and treatment areas, furniture, etc.
- HEALTH PRODUCTS: This consideration includes products that are specifically intended for the disinfection of sanitary products, classified as those belonging to:
  - Group IIa: Disinfectants for non-invasive instruments (incubators, stretchers, etc.).
  - Group IIb: Disinfectants for invasive instruments.
- MEDICINES: Disinfectants are intended for use on damaged skin: wounds, scabies, burns, skin infections, etc.

All these products are used daily in the EMS work, both in the vehicle cleaning, its equipment and in the cure and disinfection of the wounds of the patients.

Disinfectants are classified into 3 levels:

- Low level disinfectants. They are not able to destroy bacterial spores in a short period of time, mycobacteria and all non-lipid or small-sized fungi and/or viruses. The minimum contact time for low level disinfection is 10 minutes.
- Intermediate level disinfectants. They do not necessarily eliminate bacterial spores, but inactivate vegetative bacteria. The minimum contact time for intermediate level disinfection with these disinfectants is 10 minutes.
- High level disinfectants. They inactivate all vegetative forms of microorganisms, but do not destroy all forms of microbial life, since they do not always eliminate all spores. Most require a time of about 20 minutes to perform a high-level disinfecting action; Some require a prolonged contact time (between 6 and 10 hours, depending on the disinfectant) to destroy bacterial spores. The initial cleaning of the object is essential for the disinfection to be effective, since many disinfectants totally or partially lose their activity in the presence of organic matter.

The most common antiseptics are: 70° ethyl alcohol, chlorhexidine, hexetidine, iodinated povidone, hydrogen peroxide and disinfectants: Benzyl-C12-18-alkyldimethyl-choride + Alkylopropylendiamine-1,5-bisguanidinium acetate and (N, N-didecyl-N-methyl-poly/oxyethylammonium-propionate + Alkylpropylendiamine-1,5-bis-guanidiniumacetate.

The risks of these products are mainly irritant and inflammable, so during their manipulation, it is necessary to use PPE of skin protection and spectacles, and in the case of cleaning and disinfection of the assistance room it is also required to use face mask or mask.

3.3 *Risks during handling of medications and compressed gases*

Both during the equipment review (see Figure 6) and during patient care, EMS personnel handle pressurized gases (oxygen) and medicines, which have different chemical risks.

We will clasify dangerous medication into 3 groups:

- Anaesthetic drugs
- Cytostatic/cytotoxic drugs
- Substances which endanger the reproduction

In our case we took ketamine, etomidate, and midazolam as anesthetics; the medication that in our service is cytotoxic is phenytoin and the dangerous for reproduction of valproic acid.

The pressurized gases present in the ambushes are the oxygen cylinders that are fixed and portable.

Figure 6. Review of ambulance equipment.

The main risk is that these are oxidizing products and that adequate preventive measures must be applied in their handling.

4 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The PPEs most commonly used in EMS at respiratory, skin and mucous membrane protection level are:

- Respiratory: FFP2 and 3 (filter for particles) mask.
- Eye protection: goggles against the projection of particles
- Hand protection: nitrile gloves
- Skin protection: uniform, that after the observed risks the systematic use of long sleeves is recommended both in winter and in winter (mitigating the higher thermal load with suitable materials in the clothes).
- Foot protection, with safety boots with toe and reinforced sole to prevent pricking with needles and glass.

After assessing the different risks, these PPEs are adequate and sufficient for day-to-day work; in the case of large CBRN risks and with certain disinfection products, one must wear suits and another specific PPE.

This would be sufficient at a general level, afterwards each company and organization must check its specific products and decide if the PPE delivered to their workers is adequate. To do this, they should review the safety data sheets.

5 PREVENTIVE ACTIONS

5.1 *Preventive actions during vehicle maintenance and traffic accidents*

During vehicles maintenance, the batteries should not be tampered and should be repaired by qualified personnel in case of breakage.

In the case of assisting victims in a traffic accident, it will be important for EMS personnel to pay particular attention to batteries damage, and in the event of acid leakage, the protection of the respiratory tract should be performed immediately. Also avoid touching the liquid with clothes or gloves, since they are not the suitable ones.

5.2 *Preventive actions during the cleaning and disinfection of the vehicle, equipment and patients*

The cleaning and disinfection products of the care unit must specify the means of protection to be used during its use, and in case an ambulance is disinfected and the product is found to be acting, Signaling and preventing the rest of the staff from accessing.

The usual measures of asepsis should be maintained, avoiding eating and smoking after cleaning and disinfection without having removed the gloves.

It is important to clean hands and face regularly and especially in case of splashes of products.

In case of use of disinfectant products of the passenger compartment by means of spray, facial mask must be used to avoid the contact of the product with the skin of the face.

During the cleaning of the critical and reusable semi-critical material, cleaning is carried out first with detergent and then disinfection. Different gloves should be used for each task and it is important to protect the skin and eyes during the tasks.

Since there are numerous types of disinfection products on the market, the type of disinfectant used must be checked and the instructions in the product safety data sheet must be followed.

5.3 *Preventive actions regarding handling of compressed medicinal products and gases*

In EMS, the vast majority of the medication is intravenous therefore its presentation is in ampoules, vials, pre-filled syringes and bottles. Therefore, the care in its manipulation must be greater than if it is oral medication.

Firstly, it must be handled with care in order to avoid the breakage of the glass containers presentations and therefore the risk of projection of both glass fragments and the drug.

Earlier, we talked about the most dangerous drugs, but almost all the drugs that are present in ampoules are absorbed by mucous membranes, wounds, etc., so avoid workers exposure to them. To do this, it is important to work with long-sleeved uniforms and to use nitrile or similar gloves and protective goggles.

Handling of the most dangerous drugs (those specified in section 3.3) must be done with special care and use, in addition to the above-specified, a respiratory protection mask. If a worker contacts the medication, he or she will inform the company and treat it as an occupational accident.

The manipulation of medical oxygen must be taken care of, mainly by the presentation of compressed gas, so that in case of rupture of the safety valve could move with great force and generate a work accident. Also during handling of pipes and fittings, new gloves must be fitted to avoid the presence of grease that could lead to deflagration. Personnel won't smoke or burn anything within the oxygen zone, since it is a combustion product.

6 CONCLUSION

EMS work is strongly linked to the use of different chemicals that may jeopardize the safety and health of its workers. That is why it is a risk that companies in the sector must take into account and establish safe working procedures, especially in the following situations:

- Review and maintenance of vehicles.
- Cleaning and disinfection of the vehicle and the equipment
- Care for patients who have suffered a traffic accident affected by vehicle fluids
- Manipulation of drugs and medical oxygen and disinfection of patient's wounds.

In addition, workers should be trained in these practices and provide PPE for the products they use in their EMS.

The EMS, like all other companies, must have a record with the safety data sheets of its chemicals through a database to establish the correct action in the event of any worker suffering an accident Related to the chemical.

Efforts should be made to modify chemicals to less risky chemicals wherever possible. And these products should be prevented from being stored or used in inappropriate or improperly labeled packaging.

The company must verify that all companies that have subcontracted follow the same indications and procedures established for their workers.

The PPEs commonly used by EMS workers are generally sufficient for the handling of the products we have discussed. Special PPE will be available for cleaning and disinfection work and the systemic use of PPE by all workers will be sought.

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Measures for preventing violence in emergency departments

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ABSTRACT: Despite all efforts, workplace violence remains an important unsolved issue in health care. Preventing and controlling workplace violence requires commitment from and participation by employees and managers at all levels. The objective of this study was to improve violence prevention and to reduce accidents caused by the violence in healthcare workplaces, especially in Emergency Departments (EDs), by gathering and developing prevention measures. Researchers constructed checklists for head nurses to provide a systematic approach to prevent and control workplace violence in EDs. The data was gathered by interviews, questionnaires and a literature review. Five checklists were developed. The checklists cover identification of hazards and risk assessment, measures and procedures, education and training, reporting of incidents and processing reports and safety culture. The checklists developed in this study provide a systematic and practical approach to preventing and controlling workplace violence.

1 INTRODUCTION

Despite all efforts, workplace violence remains an important unsolved issue in contemporary working life that causes psychological harm, injury and even death, not to mention economic loss. Certain high-risk occupations, such as healthcare, are especially prone to violence in the workplace (Speroni et al. 2013). Work-related violence within hospitals is a growing problem in Finland. According to Finnish occupational accident statistics, nursing staff very frequently encounter violent behavior (Hintikka & Saarela 2010). The highest numbers of occupational accidents caused by work-related violence in Finland occur in the medical and nursing fields (Hintikka & Saarela 2010). In addition, not all violent situations are included in these statistics due to under-reporting (NIOSH 2002; Wilkinson 2001). According to Duncan et al. (2001), as much as 70% of violent incidents remain unreported. Overall, the number of incidents of work-related violence in Finnish healthcare districts has increased in the 2000s. Violence occurs repeatedly in the healthcare context. The situations today are more arbitrary and difficult to predict (Vasara et al., 2012), and violence is one of the biggest safety risks in hospitals in Finland (Vasara et al. 2012; Rasimus 2002).

Within the nursing field, patients, their relatives and escorts may cause violence or threaten violence (NIOSH 2002). In addition, general problems in health care, such as long wait times, a noisy environment and 24-hour stand by, increase consumers' violent reactions. Drug treatment and customer service also contribute to healthcare professionals' vulnerability to violence and threats of violence (Anglang et al. 2013; Fernandes et al. 1999; NIOSH 1996). Violent behavior can occur because of stress felt by the client or his or her relatives, shock caused by illness or accident, the impatience of long queues, disappointment with treatment compared with their own treatment expectations or conflicts with healthcare staff (Saarela 2004; Anglang et al. 2013; Fernandes et al. 1999).

According to the Finnish Occupational Safety and Health Act (738/2002), in jobs at high risk for violence, the workplace and working conditions must minimize the threat and incidents of violence. There must be safety arrangements and equipment that aid calling for help, safety procedures that help control threatening situations, and practices that prevent or contain violent incidents.

Many measures can be taken to manage violence in the workplace and to manage occupational safety and health. These measures include a violence prevention plan, management and employee commitment, operating procedures, worksite analysis, hazard identification and assessment, communication and training, reporting systems and structural and technical solutions, which ensure adequate resources and post-incident response (OSHA 2008; Hämäläinen & Anttila 2008; Saarela 2004; Wilkinson 2001). Many actions by the leadership of emergency departments have a positive influence on workplace violence, such as education and training, mandatory reporting of events, a zero-tolerance policy, clear procedures for investigating threats of violence and procedures for dealing with a violent event (Kowalenko et al. 2012).

Safety management and workplace violence management should be actions performed daily in cooperation with the management, superiors and employees. Proper safety management decreases the number of accidents, increases workplace productivity and improves the work climate. Furthermore, the improved work climate is visible to patients and improves the quality of their treatment (Abudayyeh et al. 2006; Westrum 2004; Vredenburgh 2002). Safety culture creates a foundation for how the organization takes safety issues into account (Hämäläinen & Anttila 2008). There are different means for creating the safety culture and motivating personnel, such as examples shown by management and superiors, regularly dealing with safety issues, continuous safety training and education, instructing and orienting personnel and communicating openly. Safety education has a significant role but is not sufficient without other actions (Abudayyeh et al. 2006; Westrum 2004; Vredenburgh 2002).

Efficient communication between different levels of the organization and continuous reporting are essential elements of safety management. The personnel's motivation for and attempts at improving the safety culture provide the information offered to employees. Thus, the organization creates and maintains actions to create efficient and open communication channels, participation by personnel and taking different point of views into account (Abudayyeh et al. 2006, BS 8800:2004).

Preventing and controlling workplace violence requires commitment from and participation by employees and managers at all levels and should be part of daily work (Vasara et al. 2012). In the healthcare context, head nurses are responsible for occupational safety and health as supervisors. They should be responsible for preventing and controlling violence in their departments. They are the management level closest to those who work with patients and in other types of jobs where problems usually appear. However, head nurses have difficulty fulfilling their responsibilities because of their other duties. Thus, head nurses need simple measures that make their work as a supervisor easier (Anttila et al. 2016).

2 MATERIALS AND METHODS

This study employed qualitative and constructive research approaches. Six Finnish hospital districts (six emergency departments) participated in the study. All case emergency departments were public. The constructive research approach was applied in creating checklists for head nurses to provide a systematic approach to preventing and controlling workplace violence in EDs. The checklists are based on existing knowledge and the heuristic research process.

Creating the checklists began with defining the requirements. They were based on the occupational safety legislation and the literature. In the second phase, data on the initial situation and the need for preventing and managing violence was collected with semi-structured interviews and a questionnaire. Interviews were conducted with 27 persons: 11 nurses, three head nurses, five security officers, five health and safety representatives, one medical attendant, one health officer and one physician. Interviews were used to find out what factors enable violent situations, how violent situations are prevented and controlled and what are the biggest problems and development areas in management of violence. The questionnaire was conducted electronically, and it was sent by email to the staff of the six emergency units. A total of 178 staff members participated in the survey. Most were nurses (148), 12 were physicians and 18 were other staff members. The survey supplemented the results of the interviews. In the third phase, based on the previous phases, the researcher drafted the preliminary checklists. In the fourth phase, the preliminary checklists were tested in four hospital districts. In two districts, comments were collected during the comment sessions. During the sessions, the checklists were discussed in detail, and the issues brought up were discussed. Two head nurses, an assistant head nurse, a coordinator of well-being at work, two health and safety representatives and one security officer participated in the commentary sessions. In one district, the comments were collected by visiting with the emergency department manager in person, and in one district, the comments were collected by phone. The checklists were improved based on the comments received.

3 RESULTS

Based on the interviews and the questionnaire, head nurses of emergency departments need measures to improve their ability to consider and manage threats and violence issues as part of their supervisory work. Checklists were developed for five subjects. The topics are identification of hazards and risk assessment, measures and procedures, education and training, reporting incidents and processing reports and safety culture. The selected topics are based on the results of the study phases and current knowledge of the safety issues that affect the prevention of work-related violence.

3.1 *Identification of hazards and risk assessment*

According to the interviewees, violence risk assessments were carried out in emergency departments, but the interviewees were not aware of them. The evaluations are conducted on a general level, the results are not discussed with nurses and the results of the evaluation are not utilized in the best possible way.

The checklist (see Table 1) contains the mandatory risk assessment based on legislation and good practices for how to utilize the results of a risk assessment. The hazards need to be identified systematically, and the risks need to be evaluated. Measures for removing or minimizing risk need to be implemented. The results of the risk assessment should be used to design the induction. The staff should be part of the risk management process.

3.2 *Measures and procedures*

According to the interviews and questionnaire, the departments have many safety procedures, but the nursing staff was not aware of them or did not remember them. Many of the procedures are general, not specifically for the needs of emergency departments. Specific procedures for emergency departments were considered useful. In addition, practices and guidelines for managing threats and violence in the emergency department were needed, especially guidelines and procedures for preventing and managing violence with different parties working at emergency departments. All the procedures were forgotten unless they were revised regularly. The department meetings and trainings were considered suitable for that.

The developed checklist (see Table 2) contains the essential things to consider regarding measures and procedures. The procedures need to be tailored to the needs of the department, and the staff should be aware of the procedures. Written versions of the procedures should be available, but they should also be reviewed regularly with the staff. Personnel should be committed to work following the procedures. Several different parties work in the emergency department. The guidelines and procedures should be discussed with all who work in the department.

Table 1. Checklist: Identification of hazards and risk assessment.

Identification of hazards and risk assessment
Work-related threats and violence risks are taken into account as part of the risk assessment in the department.
Threats and violence risks are systematically evaluated, e.g., using risk assessment forms.
A systematic risk assessment is carried out in the department least once every three years.
Risks are always assessed after an accident or after a substantial change in operations.
The results of the risk assessment are used to design the induction.
Threat and violence reports are utilized in the risk assessment.
The results of the risk assessment are utilized in developing the emergency department plan.
The results of the risk assessment are discussed with the staff.
The risks of threats and violence and measures for removing the risks are evaluated with the staff.

Table 2. Checklist: Measures and procedures.

Measures and procedures
Guidelines for EDs have been developed for dealing with violent situations.
Short, written procedures for threats and violent situations are easily accessible and readable by staff.
Guidelines for threats and violent situations are discussed with staff annually.
It is emphasized to the staff that everyone has to follow common procedures.
The head nurse interferes when the procedures are not followed.
Preventing and managing violence is regularly discussed with the staff, for example, in monthly meetings.
Guidelines and procedures have been discussed with all parties who work in the emergency department (e.g., emergency care, police, security guards).

3.3 *Education and training*

In the interviews, education and training were considered to have an important role in preventing violence. The interviewees felt that they had not received enough training for preventing and managing violence. The nursing staff felt that they needed training for reassuring threatening or unpredictable patients or escorts, especially training for encounters and interactions. The same need for training appeared in the questionnaire results. The interviewees also felt that they needed practical training for handling violent situations. According to the interviewees, nurses' knowledge and ability to act and speak properly in threatening situations need to be improved. They considered it problematic that only some of the staff could be trained. New employees could not get training at all. Practical trainings for violent situations were considered necessary.

The education and training checklist (see Table 3) helps the head nurse take into account the most important issues of violence education. Employee orientation should include training about preventing and managing violence. Staff should be provided with training on violence issues regularly and should be allowed to participate in training. Training for preventing and managing violence should include real-world practices.

Table 3. Education and training.

Education and training
New employees are familiarized with preventing and managing threats and violence situations.
Staff is regularly trained (e.g., once a year) on the following issues: identifying and encountering a threatening person, preventing threats and violence and managing threatening and violent situations.
Dealing with different situations is practiced once a year.
Each employee participates at least every other year in some training regarding threat and violence.
A record is kept on trainings and the persons involved.
There is a designated person who assists staff in preventing and managing violence.

3.4 *Reporting incidents and processing reports*

According to the interviews, the definitions of violent situations were unclear to staff. This lack of clarity contributed to the reporting of threats and violent situations. According to the interviews and the questionnaire results, violent situations are more common than the statistics show. The threshold for reporting was high in emergency departments, and reports were not made. According to the questionnaire results, 40% of the respondents always report physical violent incidents, 29% sometimes report the incidents and 19% rarely report incidents through the reporting system. Nine percent of the respondents stated they never make a report. Regarding threats, 19% always report threats, 30% sometimes report threats and 34% rarely report threats through the reporting system. 17% of respondents stated they never report threats. Reporting was considered unnecessary. The interviews did not know why the incidents should be reported. The processing of the reports was not familiar to the interviewees. Most of the incidents were discussed with coworkers; only some of the incidents were discussed with head nurses or safety officers.

The checklist (see Table 4) is a collection of issues that can help head nurses promote reporting activity. It is discussed with the staff when a report is necessary to make and the staff is reminded of the importance of reporting incidents. The staff knows why incident reports should be made, how incidents are used in the organization and to what they have led. After a violent incident, it is necessary to carry out an accident investigation.

Table 4. Checklist: Reporting incidents and processing reports.

Reporting incidents and processing reports
The supervisor discusses threats and violent incidents with the staff.
It has been discussed with the staff when it is necessary to report an incident of violence.
Personnel are reminded to report violent incidents.
Staff is informed (e.g., by e-mail, department hours) why reporting threats and violent incidents is important.
Summaries of the reported incidents (how many and what are the cases) are discussed with the staff.
The staff is informed when the summaries of the reported incidents are discussed.
The staff is informed what kind of measures the reported incidents have led to.
In accidents, an accident investigation is carried out according to the workplace procedures.

3.5 *Safety culture*

According to the interviews and questionnaire results, many nurses consider violent incidents part of their work. Some incidents were interpreted as normal situations, because of the patient's illness. Incidents occur daily, and the staff has become accustomed to them. They are no longer considered violent incidents, and they are not reported. It was not clear when a patient's behavior is affected and what kind of behavior is acceptable. Often, only the behavior of the nurse was considered. However, the interviewees consider the behavior of the nurse one of the most significant preventative factors. Interviews emphasized the importance of patient safety in health care. The interviewees did not see the effects of occupational safety on patient safety. According to the interviews and questionnaire results, the prevention and management of violence should more perceptible.

The safety culture checklist (see Table 5) contains issues that are important and can affect the attitude toward violence perpetuated against staff. Preventing and managing violence are considered issues between staff and clients. With staff, what kind of behavior is allowed by staff, as well as patients is discussed. All activities communicate that staff safety is as important as patient safety.

The checklists describe the target level for which the situation of the department can be compared. Only the most important issues were collected, because the lists should be short and simple, and they would help head nurses focus on the most important issues for preventing and managing violence.

The checklists were evaluated as suitable for their purpose. In the testing phase, discussion was held on different time series regarding participation in training and risk assessment. The issues related to the exploitation of the results of the risk assessment were found to be useful. Based on the

Table 5. Checklist: Safety culture.

Safety culture
Preventing and managing violence are regularly discussed.
What kind of behavior by patients is not allowed is discussed and agreed on.
Patients are told that improper behavior will not be accepted, for example, through posters, TV monitors, brochures and news releases.
Employees know that the patient's misbehavior must be responded to a professional manner.
It is discussed with the staff what kind of behavior is professional.
Workers are required to participate in training related to violence.
Personnel safety is considered as important as patient safety.

feedback, important and essential issues were collected for the checklists. The issues are not new on based on the feedback, but the aggregation of the issues into a single list helps them to be considered in daily work. The lists were also considered suitable as a frame of discussion, and they can be used in work groups involved with preventing violence.

4 DISCUSSION

It is widely recognized that employee participation improves occupational safety management (Frick 2011; Lin & Mills 2001; Walters & Frick 2000). The commitment of employees is seen to be an important factor in safety management. The checklists developed in this study also reflect these issues and their importance. Management of violence requires the entire staff to participate. The head nurse is responsible for engaging and involving staff in managing violence.

The topics selected for the checklists (identification of hazards and risk assessment, measures and procedures, education and training, reporting incidents and processing reports and safety culture) are commonly known to be essential occupational safety issues. These topics emerged from several safety studies (OSHA 2008; Saarela 2004; Wilkinson 2001), as well as in this study. The checklists developed in this study were developed for the needs of the head nurses. The lists took into account the special features of emergency departments. The lists also sought to consider the needs of the staff so that the lists would help head nurses engage personnel in managing violence.

Violence is usually managed by structural safety, a key issue in violence management. This topic was left out of the checklists because there are many lists for structural safety, and head nurses do not generally manage these issues. They are usually managed by security managers.

Several studies (Duncan et al. 2001; Wilkinson 2001) have shown that in the healthcare sector, violent incidents are under-reported. According to studies, statistics show only a small percentage of actual violence. The results of this study support the results of previous studies. Non-reporting is a big problem. Previous studies showed that accident and violence reports provide useful information on the development of safety. This information is missing in health care. Thus, the official statistics for hospital districts show that violence is not a big problem in emergency departments, although studies show that it is an essential security risk.

In this study, checklists for violence management were developed for the hospital environment especially for head nurses of EDs. The checklists can also be utilized by other departments and supervisors. The lists are recommended for use in meetings concerned with violence.

There should be more discussion and violence issues should be a focus in emergency departments. ED staff has become accustomed to violence. Changing attitudes requires long-term work in departments. Zero tolerance of violence should be visible in all management and operations.

5 CONCLUSION

The checklists developed in this study provide a systematic approach to preventing and controlling workplace violence and accidents caused by violence, especially in emergency departments. Identifying the most important violence hazards and related safety measures help head nurses to focus their daily management activities and essential safety management tasks. It helps organizations improve safety culture systematically and more effectively integrate violence prevention as part of their health and safety management and daily work.

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Safety culture assurance by auditing in a nuclear power plant construction project

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ABSTRACT: An essential element of assuring a good safety culture is being aware of its current state. Currently, safety culture is typically assessed by means of resource-heavy methodologies, which are not best suited for contemporary organizations such as networked projects. In this paper we will describe the safety culture auditing process used in the supply chain of Fennovoima Hanhikivi-1 nuclear power construction project. Summary findings from five audits are presented. Finally, the limits and possibilities of utilizing auditing in the context of safety culture are discussed, and good practices for safety culture auditing are proposed.

1 INTRODUCTION

Since the late 1980s, in the aftermath of several severe accidents, safety culture has become a concept to illustrate the organizational and cultural factors that influence safety in high-risk organizations. An important aspect of assuring a good safety culture is being aware of its current state. Several practical guidelines have been proposed that describe elaborate processes for conducting comprehensive safety culture assessments (e.g. IAEA, 2016a, 2016b; Oedewald et al., 2011). The purpose of safety culture assessments is to understand the cultural causes of safety issues, identify strengths and improvement opportunities, guide continuous improvement and engage in organizational self-reflection (IAEA, 2016a, 2016b). Due to the complex and multi-level nature of culture, assessing safety culture is far from straightforward, and it is regarded to require a profound inquiry into the organization and a rigorous methodology to uncover the underlying cultural assumptions (Guldenmund, 2000; Hale, 2000; Oedewald et al., 2011; Reiman & Oedewald, 2009). Often the resulting assessment practices are highly time and resource-demanding.

Contemporary safety-critical organizations often consist of a network of companies and chains of subcontractors, each of which can have an influence on overall safety. Due to the sheer size and extent of the resulting networked organization, relying only on traditional safety culture assessments might not be viable and more efficient and light-weight complementary solutions are required. There is thus an increasing need to carry out safety culture evaluations that cover a lot of ground in a short amount of time.

We propose that adapting the method of quality auditing for safety culture assessment can help address this issue. Quality auditing is traditionally used to examine the conformity of the management system to a specific set of predetermined criteria (ISO, 2011). Due to the relative formality of the method, a quick turnaround is achievable. Utilizing safety culture requirements (e.g., legislative, contractual, etc.) as criteria against which audit evidence is compared, the audit method can potentially provide a complementary means of assessment for making spot checks of safety culture in the networked organization.

In this paper we will discuss the limits and possibilities of using the method of auditing in the context of safety culture assurance. The findings and insights of the paper are based on the authors' first-hand practical experience in developing and applying a process for conducting safety culture audits in the Fennovoima Hanhikivi-1 (FH1) nuclear power plant construction project supply network. In this paper we describe an auditing process developed for assessing the safety culture in the supply chain and present selected findings from five audits conducted by the authors. In addition, we will provide insight into what sort of information it is possible to gain of the supply network's safety culture by means of auditing, and what is likely to be missed, based on our experience in conducting safety culture audits. Finally, we suggest a set of good practices for utilizing auditing for safety culture assurance.

2 AUDITING AND SAFETY CULTURE

2.1 *Introduction to auditing*

Auditing comes in many forms and has been utilized in domains such as financing, quality, environmental and safety management, and societal impact. In this paper we will focus on management system auditing (esp. drawing from quality auditing) and examining how it can be adapted for safety culture evaluations. The International Organization for Standardization defines an audit in the context of quality management system evaluation as follows: *"[Audit is] systematic, independent and documented process for obtaining objective evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled."* (ISO, 2015, p. 34) The essence of audits therefore includes the following three elements:

- Establishing a set of audit criteria
- Collecting objective evidence
- Evaluating whether the evidence demonstrates compliance to the criteria
- Systematic approach and independency

Quality audits can be classified in many ways. Russell (2013) proposes three means of classification that relate to the following characteristics:

- The relationship between the auditor and auditee organizations
- The entity being audited
- The purpose of the audit

The first classification results in a typology that defines the *relationship between auditor and the auditee organizations*. This relates, for example, to the extent and nature of independency, and defines the authority that defines audit criteria. Commonly, three types of audit categories result from this classification: first, second and third-party audits (ISO, 2011). An audit where the auditor and auditee organizations are the same is called an *internal audit* (i.e. first-party). Such audits intend to evaluate the extent to which the organization meets the objectives it has set to itself (e.g. Pickett & Pickett, 2003). In case the auditee organization belongs to the supply network of the auditor organization, the audit is called a *supplier audit* (i.e. second-party audit). In supplier audits, the auditor (owner/customer) aims to verify whether the auditee (supplier) complies with the requirements (e.g. as stated in contracts) set towards its products or processes. The third main type of audit is *certification audit* (i.e. third-party audit), where the auditor and auditee organizations are completely independent and free of conflict of interest (Russell, 2013). This paper focuses on second-party audits.

The second classification results in a typology that distinguishes *what* is being audited. For instance, Russell (2013) distinguishes the following entities that can be audited: product, process and system. Product audits are focused on a specific product that results from the activities of the auditee organization. This can include physical objects, immaterial commodities, services, etc. Process audits, on the other hand, focus on verifying the compliance of the inputs, actions and outputs of a specific activity. Systems audits, respectively, aim to evaluate the compliance of the auditee organization's management system to the audit criteria. Unlike product or process audits, system audits is focused on all of the system's elements that can have an influence of the acceptability of the resulting product (Russell, 2013). Safety culture audits incorporate elements of both process and system audits.

The third classification defines the *purpose* of the audit. For example, Russell (2013) identifies the following four audit purposes: conformance, performance, certification and follow-up. Conformance audits aim to verify whether the auditee meets the requirements; however, they do not intend to evaluate whether the actual performance is good or not. Conversely, performance audits intend to provide information regarding the actual performance (e.g. the efficiency and effectiveness of procedures or processes) of the auditee. Certification audits are conducted by third-party audit organizations to verify that the auditee complies with a standard such as ISO 9001, ISO 14001 or ASME NQA-1, or a regulation (Russell, 2013). Follow-up audits are conducted to verify that the corrective actions to the non-conformities or other issues found in previous audits have been satisfactorily addressed.

Typically audits follow a rather standard course of action. For instance, ISO (2011) describes a typical audit process which begins with initiation phase, including activities such as establishing contact with the auditee, providing basic information (e.g. objectives, scope, methods) about the audit, requesting relevant documents and making practical arrangements. The second phase, preparation, includes the review of the documents provided by the auditee, preparing an audit plan, and assigning the responsibilities for the audit team members. The next phase, conducting the audit on-site, involves the collection of audit evidence, evaluating it against audit criteria and formulating audit findings. Audits typically begin and end with a meeting held jointly with the auditor and auditee. During the closing meeting, the findings and conclusions are presented. Finally, the audit report is prepared and distributed.

2.2 *Previous work on safety culture audits*

The role of auditing in assessing safety culture has been discussed in scientific literature occasionally. However, concrete descriptions of safety culture audit processes have rarely been proposed.

A notable exception is presented by Grote and Künzler (2000) who discuss the prospects of expanding a safety management system (SMS) audits in such a manner that they would also capture the state of safety culture. They note that a safety culture assessment method in the context of SMS audits would need to be a) applicable during the short period of time that an audit is conducted, and using limited amount of resources, b) collect sufficient amount of information to be able to draw conclusions regarding safety culture, and c) should provide a normative judgement of degree of fit between the measured state and goals or other criteria. As a solution they present a safety culture questionnaire as a complementary tool for SMS audits. Grote and Künzler (2000) conducted seven SMS audits in petrochemical plants to test out their variation of SMS audits and found that the questionnaire was a useful source of safety-related perceptions. However, they also note that their proposed auditing process was adversely influenced by things such as the limitations of the questionnaire design and that the questionnaire was the only method of assessing safety culture. The findings of this study were later replicated and the questionnaire modified by Grote (2008). The overall weakness of the auditing processes described by Grote and Künzler (2000) and Grote (2008) is that they aim to expand the SMS auditing method, rather than developing an auditing method that focuses solely on safety culture.

3 SAFETY CULTURE AUDITING PROCESS

3.1 *Context and requirements*

The FH1 nuclear power plant construction project is currently in licensing phase, with construction license application submitted and license granted expected by the end of 2018. The main contract for FH1 program and project is the EPC contract (Engineering, Procurement, and Construction). This turn-key contract constitutes the set of all requirements related to management systems and quality management of the EPC Supplier (RAOS Project Oy, a subsidiary of Rosatom). EPC Contract also sets the requirement that EPC Supplier shall communicate all relevant management systems and quality management related EPC Contract requirements as a set of contractual requirements to all of its first tier suppliers and ensure contractually that similar communication of requirements is performed by all sub-suppliers throughout the whole supply chain.

Safety culture issues are considered in all stages of contracting, from the EPC contract and the supplier approval to project implementation activities.

In addition to the EPC contract, the organizations participating in the FH1 project are bound by the Finnish legislation and regulations for nuclear safety, as defined by Nuclear Energy Act (990/1987), Nuclear Energy Decree (161/1988), STUK Regulations and YVL Guides.

Both the EPC contract and the regulations contain several specific requirements concerning safety culture. The EPC contract requires, for example, that the safety critical suppliers develop and document a Safety Culture Program and allocate resources for safety culture development. It also sets several requirements for following up and reporting on safety culture issues.

Examples of safety culture requirements in the YVL Guides defined by the Finnish Radiation and Nuclear Safety Authority (STUK) are the following two from YVL A.3, which covers the general requirements for management system for a nuclear facility (STUK, 2014, p. 7):

- *"310. The management system shall support a good safety culture. In a good safety culture, safety is of primary importance, actions are prioritized based on their safety significance, the senior management and the entire personnel are committed to a high level of safety, the atmosphere is open and fosters a questioning attitude, safety is considered systemically, and safety is continuously improved."*
- *"318. The management system shall contain procedures to make the management aware of the state of the safety culture, changes to it and, in particular, the potential deterioration of the safety culture."*

The fulfilment of these requirements by each safety-critical sub-supplier is described in two main documents: safety culture program or procedure, and implementation plan. Safety culture program should define how safety culture is and will be developed and monitored in a planned and systematic manner. The implementation plan provides more detailed list of activities taking place in the near future and it is revised at least annually. For the first tier suppliers and other sub-suppliers graded as safety significant, safety culture programs need to be submitted to Fennovoima for review and approval. Safety-critical sub-suppliers are also required to periodically summarize the results of their activities in a follow-up report that is submitted to Fennovoima for information.

3.2 *Auditing as a part of Fennovoima's safety culture program*

Fennovoima has defined a safety culture program that includes both internal activities as well as activities aimed at assuring safety culture in the supply chain. The supply chain related activities consist of trainings, working groups and other meetings that aim at facilitating the development of safety culture in the FH1 project supply chain. Auditing (management system, safety culture, etc.) is the main method of monitoring this development. Other methods include the review and approval of safety culture related documents and the analysis of non-conformities and other performance information, trending etc.

Safety culture audits are one method of monitoring the status of safety culture in the supply chain of the FH1 project.

Safety culture audits are differentiated by their depth and a graded approach is used to identify what level of audit is needed for each company. The approach identifies three levels of safety culture audits, level 3 being the lightest in scope and level 1 being the heaviest. All audits that are considered in this paper are level 2 audits, and the following description applies to this level.

Level 2 audits are carried out by a qualified lead auditor (ISO 9001) who also has experience in safety culture issues and is familiar with the context of nuclear power construction. Typically, in addition to the lead auditor, two or three safety culture specialists participate in the audit. The first author has been the lead auditor in four audits and acted as a safety culture specialist in one of the audits discussed in this paper. The second author has been acting as a safety culture specialist in all five audits. Both authors have also participated in the design of the audit method and the supply chain safety culture assurance procedure.

Level 2 safety culture audits typically last for one and a half days at the audited organization. The duration depends on, for example, the number of interviews and how many specialists are available for the audit (i.e., can the interviews be done in two parallel groups). The main part of the audit is dedicated to verifying safety culture related documentation and records in the audit meeting. The themes that are addressed include:

- Roles and responsibilities related to safety culture,
- Status of safety culture documentation (e.g., policy, program, implementation plan, status reports),
- Current and planned activities in safety culture development
- Assessments of safety culture (self-assessments, independent assessments)
- Safety culture in the supply chain
- Workforce safety competence management
- Handling of safety issues, including employee observations and safety concerns

The auditee is expected to provide a brief presentation of each of the themes, followed by specific auditors' questions and inspection of records by sample-based approach. Several documents are also required in advance for analysis.

The document analysis covers materials such as management system descriptions, plans and descriptions of safety culture related activities and results of previous safety culture assessments.

Level 2 safety culture audits may include interviews. The interviews aim to provide information on how those people, who do not have official responsibilities for the auditee's safety culture program, view safety culture and its role in their own work. The interviews are also used to verify any predefined issue that is a potential concern for the audit team (e.g. whether the interviewee has received training in safety culture issues, whether (s)he knows how to report safety observations, whether (s)he is able to give concrete examples of safety culture in daily work). The overall tone of the interviews is to be as concrete as possible and ask for examples.

The interviews include questions based on the following themes:

- How does the interviewee relate nuclear safety to own work?
- How does the interviewee conceptualize safety culture?
- Is the interviewee aware of specific safety culture related activities identified as relevant by the auditors (e.g., organization's safety culture policies and/or principles, safety culture assessment results, etc.)?
- What concrete actions has the interviewee taken to enhance or promote safety culture? What actions has the management taken?
- How does the interviewee perceive work atmosphere at the organization?
- How does the interviewee perceive openness and efficiency of communication at the organization?
- Has the interviewee participated in safety culture training or other safety culture activities?
- What does the interviewee identify as safety culture related improvement targets for the organization?

The interviews typically include both top management and shop floor personnel. Interviews are always conducted without the presence of any non-essential participants due to privacy and confidentiality reasons. This includes any observers, e.g. from the regulator, the auditee, or any other organization participating in the Hanhikivi-1 project.

Audit agenda is sent in advance to the auditee. In the agenda, the audit themes are stated, as are the job positions (e.g., "design experts", "top management representative", or "construction supervisors") that the audit team wishes to interview. The final selection of the interviewees (in case there are several people in the same position) is left to the auditee. Individuals to be interviewed are decided at the beginning of the audit. A letter requesting needed background material is also sent before the audit.

In Fennovoima's audits, there are three groups of observations as follows:

- Non-conformities
- Comments
- Positive findings

Nonconformities are issues that do not conform (or do not comply) with safety culture requirements. Comments are issues that have for some particular reason been highlighted and recorded and shall be considered as opportunities of improvement, but if not duly considered, may result later on in a non-conforming situation. Positive findings are issues that the audit team considered positive, especially from Fennovoima's point of view. The purpose of the issued findings is to highlight important aspects related to the Hanhikivi-1 project.

A short summary report including audit findings is presented to the auditee at the closing meeting. Also follow-up actions regarding these findings are agreed at this point. The auditee shall report to Fennovoima the actions that the auditee has taken to respond to the audit observations within the given time limit as defined in the summary report. The summary is signed by both parties at the end of the audit.

For the audit findings classified as non-conformities, the follow-up actions reporting to Fennovoima shall include recorded results of root cause analysis, planned corrective actions and evidence of the implementation of corrective actions including the auditee's internal assessment of corrective actions implementation efficiency. The corrective actions reporting by auditee shall be done using individual NCR reports submitted by Fennovoima. For comments, the auditee is recommended to consider the comments and perform improvement actions. The auditee is requested to report improvement actions status within the agreed schedule, i.e. within thirty days by using a form submitted by Fennovoima.

4 CASE AUDITS

4.1 *Data collection*

In this paper we describe the findings from a total of five safety culture audits conducted during 2016–2017. The auditee organizations were top-tier contractors of the Fennovoima Hanhikivi-1 project classified as highly safety significant.

The data collection included document analysis of relevant management system materials prior to the audit, interviews of relevant personnel, and the evaluation of the auditee's activities during audit meetings onsite.

During each of the audits, a number of semi-structured interviews were carried out with personnel from various levels of the organization. This resulted in a total of 49 interviews in five audits, ranging from five to twelve per audit.

The audits had three or four auditors present, depending on the availability of the auditor's resources. Advance preparation required one to two weeks, depending on the amount and quality of advance material. At least the same amount of time needs to be reserved for the follow-up.

4.2 *Example findings*

During the five safety culture audits we made a total of 11 non-conformity reports (NCRs), 17 comments and 15 positive findings. Out of the 11 NCRs, two referred only to the EPC contract as the audit criteria, and four referred only to regulations (YVL Guides). Five NCRs referred to both EPC contract and regulations (Table 1). All NCRs had a reference to either contractual or regulatory requirements, or both. Some comments did not refer to either.

The audit findings were usually formulated as narratives and they aimed to be informative rather than concise. The audit finding length ranged from 10 to 196 words ($M = 64$). When applicable, clarifications and elaboration of findings were included in the findings. For instance, some findings included descriptions of how the auditors reached the conclusion (e.g. what evidence was found or not found), or more details about the requirement(s) related to the finding.

Table 1. Distribution of references of the audit findings.

	n
Non-conformities	
Contract	2
Regulation	4
Contract and regulation	5
TOTAL	11
Comments	
Contract	1
Regulation	4
Contract and regulation	3
No references	9
TOTAL	17

The contribution of each type of audit evidence to the findings is shown in Table 2. Multiple sources of evidence contributed for some findings. All NCRs and comments were either found or confirmed during the audit meeting. Evidence found during the audit meetings also most often contributed to positive findings, along with the interviews conducted with the auditee organization's personnel. Findings from document analysis contributed primarily to NCRs and comments. None of the findings from document analysis were used as the only evidence for an NCR or a comment; instead, the auditee was asked to provide elaboration or additional information in the audit meetings on the potential issues identified during document analysis. Based on this elaboration, the potential issue was regarded as either an NCR, a comment or it was closed.

Nine categories of findings emerged as a result of the audits. The categories and their respective sub-themes are summarized and related to the audit findings in Table 3. Due to the manner in which the categories were devised and the audit findings were worded, some audits findings were related to several categories and/or sub-themes.

The most common positive finding, and demonstrated by all five auditees, was the openness of the employees. This was especially demonstrated during the interviews. For example, we viewed interviewees openly bringing up potential safety culture problems in their organizations or their ability to identify improvement areas for safety culture as evidence of openness. Another common positive finding was care during the preparation for audit, for which all except one organization received at least one positive finding. We find that the auditee's attitude and meticulousness towards safety culture audits conducted by the project owner reflects, for example, how the auditee regards and prioritizes safety culture assurance activities. This serves as an indication of the organization's preconditions to sustain good safety culture.

A typical safety culture finding that resulted in either an NCR or a comment was the lack of required organizational structures. This encompassed contractual requirements such as a lack of a safety culture program, or a lack of or limited

Table 2. The contribution of each source of evidence to the audit findings.

	Audit findings*		
Source of evidence	NCR	C	P
Audit meeting	11	17	10
Interviews	2	1	8
Document analysis	2	5	2

*Number of non-conformity reports (NCR), comments (C) and positive findings (P).

Table 3. Number of audit findings by category.

	Audit findings*		
Categories and sub-themes	NCR	C	P
Organizing			
Existence of required safety culture-related structures	2	5	–
Availability of personnel or resources	1	2	1
Commitment			
Top management commitment	2	–	1
Systematic approach			
Relation of safety culture activities to identified needs	–	3	–
Coordination or target-orientation	1	3	–
Understanding			
Understanding the concept of safety culture	1	–	1
Understanding and explicating the expected causes and effects of safety culture activities	1	–	–
Questioning attitude	–	–	1
Use of assessment methods			
Diversity of assessment methods	1	3	-
Implementation of assessment activities	–	1	1
Following up the state and trends of the state of safety culture	2	1	–
Use of improvement methods			
Diversity of improvement methods	–	2	–
Implementation of improvement methods	1	–	1
Quality of trainings	2	–	–
Following up the impact of trainings	1	–	–
Supply chain			
Supply chain safety culture assurance activities	1	1	1
Employee involvement and safety communication			
Communication interfaces (incl. language barriers) or forums of safety communication	1	2	–
Observation or safety concern systems	1	2	–
Openness	–	–	5
Care			
Preparation for the audit	–	1	4
Proactive attitude to safety culture activities	–	–	1

*Number of non-conformity reports (NCR), comments (C) and positive findings (P).

functionality of an observation or safety concern system. Evidence of the lack of structures was typically found during the audit meetings when the auditees presented their activities, or sometimes during document analysis.

Another common audit finding which was to some extent demonstrated by all auditees was a lack of diversity in the use of safety culture assessment or improvement methods. Evidence of this was found when the auditee presented their safety culture implementation processes and it was revealed that they relied on single methods for safety culture assessment (e.g., only questionnaire, or only quality management audits) or improvement (e.g., only trainings). During the audit meetings when we reviewed the methods used by the auditees for assessing or improving safety culture we also found that the methods or their implementation was sometimes lacking. Typical finding related to the quality of trainings or training materials. Evidence regarding this was found when we reviewed the training materials provided by the auditee or received the personnel's view on the auditee's safety culture training activities during the interviews.

The audits showed that some of the auditee organizations had difficulties in implementing safety culture activities in a systemic and systematic manner. For example, some auditees were not able to provide evidence or explicate how the findings from safety culture assessments are used to develop the culture, or how the safety culture improvement methods support this effort. Such evidence suggests a superficial use of the safety culture methods. In addition, some auditees could not provide evidence on how safety culture activities were coordinated and how responsibilities and distribution of safety culture work were handled.

Finally, the evidence regarding safety communication included observations of language barriers during audit meetings and interviews, or lack of evidence of the existence of safety observation or concern systems, or lack evidence that safety observations have been utilized in documented and systematic manner.

5 DISCUSSION

5.1 *Limits and possibilities of auditing safety culture*

Since the audit process described in this paper draws from management system audits, they are *limited by the same issues as management system audits* generally. Namely, the audits require a predetermined set of audit criteria. This suggests, first of all, that the content of the contractual and regulatory requirements to a large extent dictates what can be assessed in the audit: unless there are requirements that can be used as audit criteria, they cannot be used to formulate non-conformances. The issue is not as limiting in case of comments, since they do not necessarily require references to contracts or regulations. However, comments are not as substantial as audit findings either. Overall, in order for the safety culture audits to be useful for the assurance of safety culture, it is necessary that the contractual requirements (and regulations) are formulated in such a manner that they include relevant and usable content for audit criteria. Conversely, unless there are no requirements regarding safety culture in the contracts, in the regulations, or in other normative documents (e.g., industry standards and guidelines), auditing safety culture in the manner described in this paper might not hold much authority.

Another outcome of utilizing the auditing approach for safety culture is the requirement for *objective evidence*. This means, for instance, that the audit findings—especially non-conformances—cannot be formulated based on subjective intuitions or word of mouth. Instead, the auditors need to relate the findings to actual, verifiable evidence—and this requirement also applies to the auditee (i.e., they need to provide verifiable evidence). In the context of safety culture assessment, this can be an issue, because as an intangible phenomenon, it may be difficult to define, what exactly are the manifestations of safety culture that can be utilized as valid evidence of its state.

Another related concern of using auditing for evaluating safety culture is related to its *validity*. While there can be several interpretations of what is a valid safety culture measurement, it can perhaps be argued that in order to gain a comprehensive understanding of an organizational culture, an overview of the shared basic assumptions—the core cultural mechanism—should be formed (cf. Reiman & Rollenhagen, 2017). As shown by the emerging categories of audits findings resulting from the audits we conducted, our findings rarely do suggest a shared basic assumption or provide evidence of its existence or non-existence. On the other hand, the findings do provide a variety of useful insight into what kinds of cultural artifacts exist in the auditee organization, and what organizational prerequisites or preconditions the auditee has for the sustainable development of safety culture. This suggests that safety culture audits are most likely to be useful for identifying the more tangible or structural aspects of safety culture, and do not allow conclusions about basic assumptions.

The safety culture audits we conducted also demonstrated that they are a *resource-effective* way of keeping track of the safety culture activities of a large number of organizations, which is especially important in an extensive nuclear construction project network. However, due to the number of organizations participating in a nuclear power plant construction project such as Hanhikivi-1, there still is a need to balance the trade-off between thoroughness and resource use. This implies a need to utilize some sort of *graded approach*. For those organizations identified as highly safety significant or otherwise important in terms of safety culture assurance, higher frequency or deeper scope can be defined for audits (and other safety culture assessment methods can also be utilized). Respectively, for less significant organizations, a more compact safety culture audit would be more appropriate, e.g. as part of a quality management system audit.

It should also be acknowledged that *audits are limited in scope when the object of audit is safety culture*. Audits use a sample-based approach and aim to produce focused spots checks of the auditee, and therefore safety culture auditing cannot form a complete understanding of the auditee's safety culture (e.g., the basic assumptions). Thus, even though a non-conformance is not found during a particular audit, this does not necessarily serve as evidence that there are no non-conformances in any part of the system: they were just not discovered during that particular audit.

5.2 *Some good practices for safety culture audits*

Based on the real-life application of the safety culture auditing process, we propose the following good practices for those attempting to use audits as a tool for assessing safety culture:

- *Set valid and constructive contractual requirements for safety culture*: they allow the owner to control and enforce safety culture activities across the supply network, and provide criteria for audits. It is recommended to include to these criteria a requirement for the auditee to conduct its own safety culture assessments. These provide concise information to the auditors.
- *Set contractual requirements regarding auditing*: they enable the systematic and efficient auditing process, and give the owner access to supply network organizations.
- *Use a graded approach:* identify those organizations that require the most stringent approach to safety culture assurance and put increased effort on auditing them; this can be reflected, for example, in the audit scope or frequency.
- *Consider which is more effective, non-conformity or a comment:* Often the line between a non-conformity and a comment is very thin, and it is up to the lead auditor to decide which one it will be. We have found that comments are a very useful way of elaborating on various cultural issues that are important for nuclear safety, but, in comparison to non-conformances, they lack a clear requirement, or clear evidence from the target organization.
- *Consider the audit as an intervention in addition to evaluation:* Auditing always has an effect on the auditee, as they prepare for the audit and try to anticipate what the auditor will pay attention to. Also during and after the audit, the auditee will note the issues the auditor considers important, as well as those issues that the auditor does not seem to consider meaningful or important. The auditor can thus "teach" where the auditee should devote more attention to in future.
- *Audits are not an end-all solution for evaluating safety culture:* audits should be seen as a specialized tool that covers a limited scope of safety culture-related issues. Audit findings do not serve as a confirmation that the organization in its entirety conforms to the requirements and that the deeper levels of culture are healthy; therefore, other means of measuring of safety culture should be used to complement auditing.

6 CONCLUSIONS

In this paper we have discussed the applicability of auditing as a method of safety culture assurance in a nuclear power plant construction project. We presented an auditing process describing how audits with a special safety culture focus were conducted, and discussed the resulting audit findings. Furthermore, limits and possibilities, and good practices for safety culture audits were described. Our results suggest that auditing can be a useful tool for assuring safety culture in a supply network if the contractual and regulatory requirements for safety culture exist. The short turnaround of audits allowed evaluating the strengths and weaknesses of safety culture-related activities of a large number of organizations with a relatively small amount of resources. We found auditing to be especially useful for verifying the existence of organizational preconditions for safety culture activities. However, audits are not by themselves a comprehensive solution for safety culture assessment and should be complemented by other methods of supply chain safety culture assurance. These can include establishing workgroups or conducting complementary means of assessment such as surveys or observations.

As the method of safety culture auditing is new, the five audits described in this paper can be considered pilot audits in terms of method development. The findings will be used to improve the method. Important feedback will also be received when follow-up audits to the same companies will be carried out during the next year.

Auditing is most beneficial when the auditees have time to improve their performance based on the audit results. As the FH1 project is still in the licensing stage, the early start of safety culture auditing gives a good opportunity for continuous improvement.

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What kind of prevention cultures are prevailing? Typical dialogues on occupational safety and health in German companies

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ABSTRACT: Almost every second German enterprise lacks a documented risk assessment. Even less than 20% of all companies live the process of continuously improving health and safety performance. Nevertheless there is a fundamental attention in economy for health and safety issues. Which ways are taken by enterprises instead of or besides legally prescribed ones to deal with occupational health and safety issues will be discussed. It will be revealed which basic assumptions and shared orientations are underlying the correlated types of prevention culture. On the basis of 50 qualitative interviews with managers, OSH professionals and works councils possibilities to identify these prevention types are described as well as target-group-specific approaches to reach and encourage enterprises belonging to different types of prevention culture to intensify their efforts in working on health and safety.

1 BACKGROUND

1.1 *Current findings*

According to the latest representative companies' survey realized in a five-year cycle within the evaluation of the Joint German OSH Strategy "GDA" in 2015 as much as 46% of all enterprises in Germany were lacking a written risk assessment (2011: 49%). These companies are mainly small and medium enterprises representing only about 20% of all employees. But also the thin majority of German companies (54%) that do have a written risk assessment (RA) in most cases do not entirely comply with all legally prescribed steps of risk assessment process (RAP) stipulated by EU's Framework Directive (FD, 89/391/EC) and by national law. Within the mandatory RAP compliance does not only mean applying solid (technical) knowledge to business processes but initiating a continuous improvement process of identifying hazards (first step), assessing severity and probability of occurrence (second step), deploying appropriate preventive measures (third step) and evaluating efficacy of these measures (forth step). As current figures show in 2015 only 13% (2011: 15%) of all companies equipped with RA also reached the final step of RAP (Schmitt-Howe 2016). The figures do not provide information about the frequency of reaching this final step. We do not know how often and in which intervals companies conduct RAP's. But what figures show is, that roughly half of RA conducting companies do reach step three, i.e. they are deploying appropriate preventive measures. Having done so, roughly two thirds of these companies do also evaluate efficacy of the measures they thought appropriate (2015: 56%; 2011: 69%). These findings are sobering. Although legally prescribed everywhere within EU only a small minority not only of German companies really live the process of continuously improving health and safety performance (Schmitt & Hammer 2015).

On the other hand there are indicators for a fundamental attention in economy for health and safety issues. One of those indicators is the high performance rate concerning OSH instruction on the job which 91% of companies say they conduct (2011: 93%), most of them on the mandatory occasions for instruction or even regularly in certain intervals. Even small and smallest companies state, that they do conduct OSH instruction to a hardly lesser share than average. And so do employees: 85% of employees state in 2015 for example, that they were instructed about save handling of machinery and equipment (2011: 83%). The approval rate of instruction about other health and safety issues like handling of biological and hazardous substances fluctuates between 61% and 84%. The minimal but growing approval percentage occurred among employees concerning the question, if they have received instruction about methods of work organisation suitable to avoid work-related stresses and strains (2015: 61%; 2011: 42%). These findings refer to what we can call fundamental attention for OSH or basic OSH communication throughout the whole economy. Even "new" OSH topics like stress reducing methods of work organisation are getting constantly more important in in-plant instruction and dialogues.

1.2 *Bridging the gap*

If there is at least fundamental attention for OSH in economy but only poor implementation of—since about 25 years—legally prescribed OSH procedures like RAP, time has come to have a look at the ways that are taken by companies instead of or besides mandatory ones to deal with occupational health and safety issues. Employee's health and safety is recognized by companies as a management task, although in most cases as a less important management task. Regardless of whether seen more or less important OSH issues indeed are talking points and to a certain degree part of the in-plant dialogue in every company. Therefore a mainly qualitative research project of the Federal German Institute for Occupational Safety and Health has analyzed in-plant OSH dialogues to explore the action guiding interpretive patterns or mind-sets underlying common OSH communication. Basic assumptions about OSH were explored as well as different orientations, shared prevention values and hazard perceptions within organizations. Choosing an observation rather than an evaluation approach involves the aim to generate knowledge about how to reach companies in different contexts and with different types of prevention culture best. As Hasle pointed out "research in state regulation is mainly aimed at compliance and efficiency of public administration, while little attention is paid to why and how public and private organizations (…) are to improve their working environment (Hasle 2014)" or not. Contributing to bridge this research gap one starting point of this paper is the key assumption, that there cannot be no prevention culture within a public or private organization. The preventive standards might be poor, hazards might be underestimated and orientations in dealing with OSH as a management task might be inappropriate as seen from the governmental perspective, but if prevention means "preparing for uncertain future losses by seeking to reduce either the probability of occurrence of losses or their extent (Luhmann, N. 2008)", every company has a fundamental interest in doing prevention. If so we can define prevention culture as the specific way of everyday evaluating health or other risks within the business process, making (rational) decisions and taking the possible consequences of these decisions more or less into account. Regardless whether always conscious this is what every company does by its typical organizational behaviour that especially in case of loss will be interpreted as taken decisions. Only members of an organization have available the tacit knowledge about their organizational culture, i.e. about "the way we do things around here (Schein 1990)". This knowledge informs everyday decision making also in health and safety issues. It has to be taken as action guiding and can be seen as conjunctive between members of organizations. Therefore looking at the tacit knowledge about prevention culture as – often between the lines - expressed by in-plant OSH dialogues enables us to shed light on a wide range of different prevention culture types. For the reconstruction of the here presented typology the so called "documentary method" (Bohnsack 2010) in tradition of the Karl Mannheim's sociology of knowledge was used.

2 RESEARCH DESIGN

2.1 *Interview types and discussion guide*

Concerning data collection two types of qualitative interviews were used: In enterprises with 50 or more employees as a rule a group interview was conducted with 3–4 representatives of relevant in-plant function groups, i.e. (i) one chief executive as the addressee of all OSH acts and regulations; (ii) one of the two OSH experts whose provision is mandatory for each company employer in Germany, namely either an occupational safety specialist or occupational physician who works in-plant or as an external consultant for the company; and (iii) one trade union representative if there was one. In enterprises with less than 50 employees the semi-structured interview was conducted with the working proprietor only. However, if the proprietor wanted to bring in a second respondent, for example in the case of two equal-ranking chief executives, this was accepted. These two interview options both were conducted in a problem-centered style (Witzel, A. 2000 & Witzel, A. & Reiter, H. 2012).

Since "cultural origins and dynamics can sometimes be observed only in the power centers where elements of the culture are created and changed by founders, leaders, and powerful managers (Schein 1990)" in the given context of OSH issues the above mentioned function groups were taken for key agents of implementing a prevention culture and therefore target groups for interviews.

The qualitative discussion guide raised the following four main topics: (i) anchoring and roles in OSH; (ii) change processes and cooperation, including looking back at the companies' histories; (iii) in-plant communication about OSH and learning; and (iv) corporate OSH identity and motivation. All interviews took place in the company's premises. The companies selected for interviews were located in any part of Germany. The interviewees were recruited through gate keepers such as chambers of crafts and trade, trade unions, employers' associations, regional business networks, science networks, and sometimes also by directly contacting companies cited in the business sections of newspapers.

To limit the unavoidable tendency toward positive selection of companies willing to be interviewed about OSH matters, there was one invariable sampling rule set by the Federal Institute; namely, that recruitment is never organized by labor inspectors. This ensured that the interviews were not constrained and provided the strongest standard of data privacy.

2.2 *Sampling per sector group quadrants*

As shown in table 1 the sampling process has been aligned with sector group quadrants compiled on the basis of the following two hypotheses: (i) the more obvious the hazards in the work-place, the more intense the OSH engagement of the company; and (ii) the higher the possible costs of non-compliance in OSH itself or in spheres that impinge on OSH such as consumer safety and environmental law, the higher the probability of intense OSH engagement.

These hypotheses were used to construct a two-dimensional coordinate system generated by the horizontal dimension of obviousness of hazards or exposures and the vertical dimension of possible costs of non-compliance. Sector groups with a similar level of safety risks were clustered into the four quadrants in order to enable sampling of contrasting businesses. To assist the decision on allocation to quadrant I, II, III or IV, among others the German Social Accident Insurance's high, medium or low risk categorization of economic sectors was used.

Table 1. Sampling technique.

Cost of non-compliance	Obviousness of hazards/exposures	
	Lower	Higher
Higher	**Quadrant I** Food industry Health care (incl. pharmacies) Retail trade Hotel industry	**Quadrant II** Construction Chemistry Paper industry Water supply Sewage and waste Automotive industry Crafts; Forestry
Number of interviews	*∑ = 13*	*∑ = 20*
Lower	**Quadrant IV** Service industries: IT services Real estate broking	**Quadrant III** Traffic and logistics
Number of interviews	*∑ = 12*	*∑ = 5*

Allocation in the dimension of possible costs for non-compliance was both guided by estimation based as far as ascertainable on the number of OSH surveillance visits, regulatory actions, scandals and criminal investigations per sector (BMAS & BAUA 2014) and by findings of ESENER-2 (EU-OSHA 2015).

2.3 *Hazard framing, interaction focus and common understanding of OSH*

In a system theory perspective all enterprises, i.e. economic organizations are formally, by membership organized social systems with distinct forms of normality including specific ways to dread, to describe and to prevent calamities (Luhmann, N. 2012). Within the research project 50 qualitative (group) interviews with proprietors or working proprietors or CEOs of these organizations, with OSH-experts and, if existing, with representatives of working councils have revealed five types of action guiding interpretive patterns or mind-sets in OSH along the following three dimensions of meaning: (i) "hazard framing", i.e. the specific approach by which members of organizations think hazards can be made controllable and the extent to which their approach is advanced in making future present already today, (ii) "interaction focus", i.e. the company's focus either to internal integration which implicates intense interaction between management and employees or to external adaption to relevant surroundings like markets, customers, deliverers or society and (iii) "understanding of OSH", i.e. the concept of occupational safety and health common for the company, i.e. the aspects usually seen as part of OSH.

Three possible manifestations of "hazard framing" were elaborated within the typology: making hazards controllable A) by constantly improving prevention since health and safety are seen as unstable, B) by taking up the most striking preventive starting points since some hazards are seen as preventable, others, especially the hidden ones are not, and C) by relying on one's personal aptitude, i.e. qualification or creativity, since health and safety are mainly the result of being good businessmen or businesswomen. Self-evidently the extent of making future present already today is the smallest in C), the biggest in A).

Concerning the second dimension of meaning called "interaction focus" we have to take into account, that internal integration and adaption to relevant surroundings are both essential for the survival of every organization. Thus, no company can disregard the one or the other. Especially the experience based tacit levels of organizational culture shape both internal and external interactions as expressed in Ed Schein's definition of organizational culture as "a pattern of shared basic assumptions learned by a group as it solved its problems of external adaption and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems (Schein, Ed 2010)". Bearing in mind the equal-ranking importance of both integration and adaption the only question in this dimension can be how internal and external interactions are concretely shaped and with which intensity. As for any other aspect of organizational culture the interaction between management and employees has to be addressed also for prevention culture when speaking about internal integration. The empirically found manifestations of this "internal branch" of the dimension are BP) "basic participation", i.e. the employees have the possibility to suggest improvements and EP) "expanded participation", i.e. the management is seeking an intense dialogue with the employees. The manifestations of the "external branch" of the dimension are S) "focus on interaction with state institutions" including state law and labor inspection, M) "focus on interaction with mediators" like external OSH experts, chambers of crafts or commerce or similar associations and TP) "focus on interaction with third parties" like cooperating or competing enterprises or society.

On the basis of the empirical material the third typology dimension "understanding of OSH" has been divided in the following manifestations: T) "predominantly technical issues" are seen as aspects of OSH; TOP) "technical, organizational and individual-related issues"; QB) "predominantly questions of behavior"; CU) "comprehensive understanding of OSH including occupational health promotion and M) OSH is framed like a management system. Table 2 provides a first overview on the titles and positions of the five types of action guiding mind-sets in managing OSH within a two-dimensional space built by "hazard framing" and "interaction focus" which are the most important two dimensions.

Table 2. Types of action guiding OSH mind-sets.

	"Hazard framing" (prevention approach)		
Inter-action focus	Constantly improving (A)	Taking up starting points (B)	Relying on own aptitude (C)
on Integration	Type 1: *4** Own Culture	Type 3: *8* Humans are central a) All is behavior b) Participatory care	Type 5: *12* Self-reference a) Pros b) Bricolage
on Adaption		Type 2: *6* Key figures Type 4: *20* Technocrats a) Apt pupils b) Critics	Σ = *50 cases**

*Figures in cursive characters indicate the number of cases.

3 MAIN FINDINGS

3.1 *Description of five types*

Exclusively big companies were assigned to type 1 called "own culture". The companies belonging to this "front runner type" were found in high-risk sectors like chemistry, paper and construction industry but also in nutrition industry and IT-services. Companies of this type have a vision or mission in OSH, they are precautious, i.e. they integrate also very seldom hazards in their prevention work which is constantly improved since stagnation is seen as regression. These companies are usually committed to ambitious OSH approaches like "vision zero". OSH regulations are only perceived as a minimum standard. Health and safety values are communicated by all management levels from top to first-line management. Employees are encouraged to identify with and live the OSH values of the company in everyday life since these values are part of the corporate identity. These companies usually take part in—sometimes even international—benchmarking processes and are in most cases engaged in corporate social responsibility projects. Most of them run at least on management system. In one of four cases the today reached high standard of OSH performance has been described as a consequence of a fatal accident in the history of the firm.

Type 2 called "key figures" is also a big company's type found in chemistry and automotive industry as well as in water economy and again among IT services. Belonging to this type means controlling key figures in every management sphere including OSH and managing target improvements mainly by process instructions given to the employees. Companies belonging to this type were successful in improving OSH in the past. But today they face a residuum of a certain number of accidents that seem to be ineradicable. These accidents are believed to be not preventable. OSH experts working for the companies of this type often anticipate that working on prevention culture is probably the only means to diminish the residuum accident figure further. But they do not know how to start the necessary new form of internal integration. The companies of this type lack a standard communication strategy concerning OSH values as part of their corporate identity. Since they run a systematic key figures approach in almost every management sphere it is easy for these companies to watch the state's OSH regulations. Usually these firms are in close dialogue with the responsible labor inspectors whom they invite proactively to visit their company.

Small, medium and big companies were assigned by the research team to type 3 "humans are central". This type seems to be a "no matter what size type" found in production as well as in services except traffic and logistics. They have in common that they see communication as the key success factor for a frictionless workflow and therefore for good OSH performance as well as economic outcome. Employees are seen as the most important resource. Companies of type 3 are convinced that the best way to manage OSH is to create relevant behavioral standards by an ongoing process of discussion with employees. In these companies there are a lot of occasions to talk about occupational health and safety issues. Employees are invited to participate in the discussion about what is needed and how everybody has to behave in order to enable safe and healthy work. These companies do not linger to go even unusual ways by e.g. offering a work place assessment by a physical therapist. On the other hand these firms always expect cases of human failure. They are convinced that these cases are not preventable at the end of the day. Organizational and sometimes also technical OSH requirements are less regarded, in some cases even ignored by these companies unless labor inspection is visiting them. A certain proportion of these firms do not even know any OSH regulation. In-house brainstorming has priority over law among them. Type 3 can be divided in two further subtypes: 3a. "All is behavior" and 3b. "Participatory care". The difference between these subtypes is concerning internal integration, i.e. the interaction with employees. "All is behavior" companies place special importance on initiative of employees. They support employees in all they need for their safety and health if they demand it. But without initiative by employees these firms hardly get active since they are convinced that workflow is operating best if employees themselves or line managers are taking care that they can work healthy and safely. "Participatory care" firms run a different approach in this regard. They also see employees as the most important resource of the company and feel responsible to care for them proactively to keep this resource strong. Employees of these companies are expected to participate e.g. in health promoting seminars or to use ergonomic equipment in everyday work. But their initiative is not decisive for getting these offers.

The biggest number, i.e. twenty companies of the sample were assigned to "the technocrats" (type 4). Companies of this type were found in all sectors and sizes. For them it is most important to watch the law, i.e. to fulfill all OSH regulations which they perceive mainly as a matter of providing employees with safe technical equipment. Their "hazard framing" tends to see other than technical risks as something difficult or strange. Precaution in the sense of trying to prevent also unexpected or seldom hazards is seen as excessive demand they are not willing to meet. Almost the same can be said about non-technical hazards. They are perceived as hardly manageable and therefore hardly preventable. Usually these companies do not feel responsible for those hazards. If emotional stress of employees or other so called new risks are addressed anyway, companies of this type tend to solve the problem by technical means, for example by dividing one office in two in order to separate colleagues who are in conflict with each other. Non-technical means as such are mostly seen as "nice to have", i.e. not really necessary. The focus of these firms lies clearly on external adaption and here on interaction with the state and its law. Providing safe equipment is seen as a form of appreciation for employees. But participation in managing OSH issues is limited. Usually employees are expected to wear personal safety gear and to report danger spots and damages, but they are not invited to discuss what is needed or how things have to be done. Type 4 is to be divided in two subtypes too: 4a. "apt pupils" and 4b. "critics". The difference between these subtypes is concerning external adaption, i.e. the interaction with the state. "Apt pupil" companies consider the state's OSH regulations basically useful. They feel competent to fulfill the regulations, especially in most of their technical parts. For some regulations they ask for more implementation assistance by the state. But on the whole they are content with the law and with labor inspection whom they ask time by time proactively for advice. In contrast the "critics" are happy if they can limit the contact with labor inspection to an absolute minimum. Companies of this subtype often know the regulations better than average and are aware of occurring contradictions between OSH regulations and other law sectors. They feel attacked in their personal integrity by these contradictions and consider the regulations at these points non-realistic and not useful. For example hygiene regulations demand an easy rinsable floor in a slaughterhouse, OSH regulations a nonslip grippy one. "Critics" feel that all these regulations shorten their freedom to conduct a business. They suspect state instructions and think that the number of regulations is much too big and should be reduced. Nevertheless their interaction focus remains the same as for "apt people", only in form of a negative relationship to the state, its representatives and its law.

Type 5 called "self-reference" is the type of small company's only (up to 35 employees). The cases that were assigned to the type were found in crafts, especially construction crafts, pharmacies and hotel business, i.e. in traditional parts of economy on the one hand and in IT services, especially among start-ups that offer digital services on the other hand. What these little businesses have in common is that they rely almost entirely on themselves, their own experience and judgement. They also do so in OSH. Their prevention approach is practical. They consider most hazards theoretical since accidents or other losses have hardly taken place in their everyday working practice. Working proprietors of this type are convinced that their aptitude and the aptitude of their employees is enough to get along with hazardous situations. In case they belong to traditional parts of economy aptitude for these firms means vocational education (sub-type 5a. "pros"). They argue that OSH was a subject in professional training. So, for them professional work is safe work. In case they belong to the new economy of digital start-ups aptitude can be seen first of all as creativity (sub-type 5b. "bricolage"). In any case by stating, that personal aptitude is principally enough companies of this type for the most part refuse to make future hazards present. If any prevention they do prevention by investing in their personal fitness, qualification or instruction and that of their employees. Interaction focus lies on internal integration for this type of companies. Flat hierarchy is typical for these small businesses. Decisions are principally made by the working proprietor after speaking with his or her employees. These small firms believe in themselves and their team. So, a good atmosphere is important for them and participation possibilities for employees are extended. If any external OSH interaction partners are important these are mediator institutions like external OSH provision services or craft and trade chambers since labor inspection usually wasn't seen for years. Even mediators like occupational safety experts who visit the firms in many cases only once in two years are sometimes seen as "aliens" to the concrete daily working routines and accused to give only inappropriate advice. The difference between the subtypes is one of understanding of OSH here. Whereas "pros" consider mainly technical issues as parts of OSH, "bricolage" companies are mainly concerned with wellbeing and prevention of emotional stress and take these "new risks" as important OSH issues. "Bricolage" companies are additionally characterized by doing everything themselves. Even where they could draw for example on standardized occupational health promotion or return to work programs they prefer to create their own programs on grass roots level. This might be different with small enterprises belonging to traditional parts of economy.

4 CONCLUSIONS

Although contrasts of businesses were maximized by using a sampling scheme driven by sector group quadrants (Table 1) "self-reference" companies were found belonging to high risk sectors as well as belonging to low risk sectors as well. This indicates that company size is more important than sector as far as small and smallest companies are concerned.

The same can be said about the frontrunner type "own culture" as far as big companies (more than 250 employees) are concerned since only that size companies were assigned to this type.

Speaking about medium sized and big companies only type 2 "key figures" has been found more often in the high risk sector quadrant II. This indicates that bigger companies belonging to high risk sectors tend to use a management system approach more often than others. No matter what size there is a tendency to find "humans are central" companies more often in totally opposed quadrants (II; IV), i.e. as well in high risk and high compliance demand sectors of production as in low risk and low compliance demand service sectors.

A similar tendency can be found concerning the "technocrats" type. Companies belonging to opposed quadrants (I; III) tend to be assigned to this type, i.e. high compliance demand and low risk companies like health care enterprises as well as low compliance demand and high risk companies like transport and logistics firms. Maybe this indicates it is not that much risk level or possible cost of non-compliance that generate the internal integration and therefore communication centred types but the existence or non-existence of structural communication barriers in an organization. Structural communication barriers might exist for example in hospitals since different professional groups of lower and higher status work together under intense time pressure. Similarly in transport and logistics a structural communication barrier can be seen in the fact that employees are on the road most of the day. If this is valid or not, if the five presented types which were developed by explorative qualitative research occur in the described form throughout economy and in which numbers will show the analysis of a quantitative validation survey the Federal German Institute for OSH conducted among 375 companies recently. The results of this survey will not only show in which sectors and sizes the above described types are found, but also how to address them. The companies were asked by whom, i.e. by which institutions they want to get advice in which form and concerning which OSH issues. This can be helpful for OSH professionals as well as for labour inspection and social accident insurance in finding type adequate ways to promote a better prevention culture in economy.

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Translation of a safety culture training program from one industry context to another

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ABSTRACT: This paper describes and discusses a process of translating a leadership training program aimed at improving safety culture, from the construction industry in Denmark to the energy sector in Norway. The overall goal of the training program is to reduce physical attrition and improve injury/accident prevention, health, and safety culture for all parties, while at the same time improving planning and safety communication. The research question addressed in this paper is: "What factors are important to consider when translating a safety culture training program from one industrial context to another?". The theoretical framework used to discuss and understand this transfer is 'translation theory'. During the translation process the authors found many important factors to consider in the specific context of the industry, e.g. national and industry-specific regulation, the technology used, work tasks, organization of work processes and practices, risk picture, education level, and the specific 'language' of the industry.

1 INTRODUCTION

The Norwegian energy sector has in recent years experienced stagnation in their accidental injury rates, while other industry sectors (e.g. construction) have seen a decline in these rates. Energy Norway is a non-profit industry organization and member of the confederation of Norwegian Enterprises (employer organization) representing about 270 companies involved in the production, distribution and trading of electricity. In 2014, the board of Energy Norway adopted a Vision Zero related to accidents and injuries. The organization asked the authors to develop tools to help them improve the safety culture in the sector. Though generic tools already exist, before implementing a tool it is important to consider the unique interplay of the key dynamic features of this sector in specific real-life contexts. Reality can be seen as socially constructed; culture is embedded in social processes and practices, and cannot be assessed, analyzed or evaluated independently of its specific context (Le Coze 2013). Large 'one size fits all' safety culture programs often have low probability of achieving real change (Antonsen 2009), and it is necessary to have a thorough knowledge and understanding of the context before attempting to develop a tool.

An occupational safety and health (OSH) leadership training program for middle-managers, developed and successfully implemented in the construction industry in Denmark (Jeschke et al. 2017), was adapted and translated into one of the tools developed to attempt to improve safety culture in the Norwegian energy sector. The choice of the tool and subsequent translation was performed based on results from a safety climate survey, interviews with middle-managers, and a workshop with health, safety and environment (HSE) managers/coordinators in the sector.

Following from the above, the research question addressed in this paper is: "What factors are important to consider when translating a safety culture training program from one industrial context to another?". The theoretical framework used to discuss and understand this transfer is 'translation theory' (Czarniawska & Joerges 1996, Ansari et al. 2010).

2 THEORY

The past 30 years of research on accidents at work have been built on an understanding of ensuring safety that goes beyond technical rationality and traditional engineering models. The sociotechnical perspective emphasizes the interdependencies between technological and social systems, and sociotechnical systems involved in risk management include several levels ranging from legislators through managers and work planners to system operators. According to Rasmussen (1997), laws, rules, and instructions are never followed to the letter. Legislation and rules must be interpreted and implemented in the context of particular companies, and modifications of instructions are repeatedly found. The study of 'decision making' cannot be separated from a simultaneous study of the social context and value system in which it takes place, and the dynamic work process it is intended to control. Thus, it is important to include cognitive science in studies of risk (or safety and security) management (e.g. processes of sensemaking, perception, awareness, and commitment).

Sensemaking comes from preexisting symbols, norms, and social structures that people reproduce and transform rather than create from scratch. According to Weick (2001), organizational members selectively attend to their environments and then, in interaction, make collective sense of what is happening. Weick's ideas are consistent with ideas of the scholars within organizational institutionalism who emphasize the diffusion of ideas through a process of 'translation'. Instead of treating institutionally prescribed structures and practices as 'out there' and as adopted more or less 'as is', translation assumes that ideas and practices are interpreted and reformulated during the process of adoption (Greenwood et al. 2008). According to Czarniawska & Joerges (1996), the perceived attributes of an idea, the perceived characteristics of a problem and the match between them are all created, negotiated or imposed during a collective translation process, in the never ending activity of sensemaking.

According to Ansari et al. (2010), transfer and diffusion of ideas and practices across different local contexts involves the translation, co-construction, and editing activities in different cultural and social contexts, and may lead to divergence and variability in practices that are being adopted, enacted and adapted. The diffusion process across time and across adopter should be assessed as an issue of dynamic fit between idea or practice and adopter, and this fit is influenced by technical, cultural, and political factors. Different forms of fit and misfit will trigger different patterns of adaption.

Processes of translation are also important when research-based interventions are to be implemented across sectors or across countries. Similar interventions may not work similarly within different contexts, as they are embedded in open social systems with layers of contextual influences (Pawson 2006).

Often OSH interventions are evaluated with randomized controlled trials, leaving out the understanding of interventions taking place in a real-world, i.e. in dynamic and complex social systems (Lipscomb et al. 2009, Pedersen et al. 2012).

This paper describes and discusses a process of translating a leadership training program aimed at improving safety culture. There are a plethora of definitions of the concept safety culture, however most definitions emphasize safety culture as something holistic and shared. The definitions of safety culture emphasize the attitudes, behavior, or knowledge of the personnel to varying degrees (Reiman & Rollenhagen 2014). In this paper we use Pidgeon's (1991) definition of safety culture: "the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimising the exposure of employees, managers, customers and member of the public to conditions considered dangerous or injurious". Employees' perceptions of organizational support, particularly management's commitment to safety in the organization, are often claimed to be a measure of an organization's safety climate. The terms safety culture and safety climate have often been used interchangeably, although safety culture is considered to be a more complex concept than safety climate, reflecting fundamental values, norms, assumptions, and expectations (Flin et al. 2000, Skogdalen & Tveiten 2011). However, according to Guldenmund (2000), most characteristics given to culture apply equally to climate, and it is becoming accepted to view climate as a reflection of an underlying culture.

3 TOOLBOX-TRAINING PROGRAM—CONSTRUCTION INDUSTRY

The National Research Centre for the Working Environment (NRCWE) is under the Danish Ministry of Employment. NRCWE's mission is to carry out research, communicate research-based knowledge and provide training options that will enable the development of a safe and healthy working environment in Denmark (NRCWE 2017). NRCWE has developed a Toolbox-training program focused on increasing workers' active participation and improving two-way communication (Jeschke et al. 2017).

A traditional way of communication is toolbox meetings (toolbox talks, tailgate meetings, etc.), which is a popular tool used in construction (and other industries) in many countries (Esmaeili & Hallowell 2012, Hinze 2003). These brief meetings typically involve a foreman's preparation and delivery of a specific OSH topic with his/her crew before work or during breaks. However, foremen and workers often end up having to make many crucial OSH decisions on a daily basis, and the daily OSH communication between a foreman and his work crew, colleagues, leaders, customers and other construction professions mainly addresses production issues and deadlines (Dyreborg et al. 2008, Kaskutas et al. 2013, Jeschke et al. 2017).

NRCWE's Toolbox-training program goes beyond actual toolbox meetings, and focuses on foremen's planning, safety communication and safety work site behavior throughout the working day, not only at fixed meeting times, but also in daily ad hoc meetings and discussions. A 22½ hour classroom program was developed by the project team and was carried out over five half-days (4½ hour per day), with two weeks of on-site training between training days, for a total program length of nine weeks. Training consisted of a mixture of theoretical lectures, practical casework and role-play, exchange of knowledge and experience between the participating foremen, as well as assignments to be carried out during the two weeks between each classroom session. Training focused on the central role of the foreman and the importance of dialogue, involvement and influence of employees (and other parties) to improve the daily OSH communication and planning of pre job and future tasks, and the managing of work related OSH risks. Foremen were to use the new skills and knowledge in their daily activities with their work crew(s) (Jeschke et al. 2017).

Process evaluation results showed that the eight Toolbox-training topics were relevant and useful for the majority of the foremen, who experienced positive changes in their daily work methods and interactions with their crews, colleagues, leaders, customers and other construction professions (Jeschke et al. 2017). In the current project, this Toolbox-training program was translated into a leadership training program for middle-managers aimed at improving safety culture in the Norwegian energy sector. The translation was performed by the authors, which includes one of the designers of the original Toolbox-training program.

4 METHODS

The translation in this project was performed based on results from a survey of safety climate, interviews with middle-managers, and a workshop with HSE managers/coordinators in the Norwegian energy sector. The Nordic Safety Climate Questionnaire (NOSACQ-50) (Kines et al. 2011) was used as it was developed and validated in the Nordic countries, and was based on organizational and safety climate theory, psychological theory, previous empirical research, empirical results acquired through international studies, and a continuous development process. In the questionnaire, safety climate is defined as workgroup members' shared perceptions of manager as well as workgroup safety related policies, procedures and practices. In short, safety climate reflects workers' perception of the true value of safety in an organization—as a contributing factor towards the reduction of accidental injuries (Kines et al. 2011).

NOSACQ-50 consists of 50 items across seven dimensions, i.e. shared perceptions of: 1) management safety priority, commitment and competence; 2) management safety empowerment; and 3) management safety justice; as well as shared perceptions of 4) workers' safety commitment; 5) workers' safety priority and risk non-acceptance; 6) safety communication, learning, and trust in co-workers' safety competence; and 7) workers' trust in the efficacy of safety systems. A four-step Likert type response format is used for rating, using the terms 'Strongly disagree', 'Disagree', 'Agree' and 'Strongly Agree' (Kines et al. 2011).

In the current project, a web-based version of NOSACQ-50 was distributed to managers and employees in the Norwegian energy sector. In addition, the questionnaire included: background questions (age, sex, education, work area, management level, seniority, business area, company size, work hours, shifts and night work, contact with manager, working alone or in groups, working in an office or out in the field, working on projects or regular (maintenance) tasks, and working with colleagues from own company or from other companies), questions regarding safety training, accident involvement, work environment, role conflicts, physical work requirements, and cooperation with other companies or other departments within own company.

In total, 113 of Energy Norway's member organizations were contacted and 57 companies agreed to participate in the survey. The web-based questionnaire was sent to 9187 respondents via email, and 47% (4346 respondents) answered all or parts of the questionnaire.

Furthermore, qualitative interviews were conducted with 15 middle-managers from six of Energy Norway's member companies, of which four companies had over 100 employees and two companies had under 100 employees. The interviews focused on the middle-managers' work tasks and how they work, how they relate to risk and safety, what safety measures they need, and how to adjust these safety measures to their everyday work.

Finally, twenty-five HSE-managers participated in a workshop, and data were gathered through group work, followed by plenary presentations and discussions with the researchers and representatives from Energy Norway. The groups were asked to discuss why they thought the injury rates in the sector were high, what they expected from their middle managers in terms of safety work in their companies, and if there was a gap between their expectations and the actual reality in their companies.

Based on the data from the safety climate survey, interviews and workshop, the research team developed a 'toolbox' containing different safety measures that companies in the Norwegian energy sector can use to attempt to improve their safety culture. These safety measures were informational brochures and leaflets for top managers, middle-managers and employees, score sheets for self-evaluation and discussion, safety themed playing cards, and the adapted leadership training program. In order to improve 'research to practice' and 'knowledge transfer exchange' (Van Eerd et al. 2011), the measures were developed in close cooperation with Energy Norway, and were continually evaluated and discussed through regular feedback from both Energy Norway and HSE-managers/-coordinators from Energy Norway's member organizations. The regular feedback through the development-process was important for developing the right tools for the sector, and especially important during the translation of the leadership training program to make sure the program was the right fit for the specific context of the Norwegian energy sector.

5 RESULTS

The results from the questionnaire survey showed that those responding to the survey considered the safety climate in the Norwegian Energy sector to be very good. The aggregated scores were over 3 (Agree) on all seven safety climate dimensions included in the questionnaire. However, the results also showed a statistically significant difference between employees and managers; the employees were less positive than the managers. On the other hand, results of benchmarking with employees in similar sectors in other Nordic countries showed that the employees in the Norwegian energy sector were more positive to the safety climate than in the other countries.

However, three dimensions stood apart from the rest with somewhat lower mean values. These dimensions were management safety empowerment, management safety justice, and workers' safety priority and risk non-acceptance. Furthermore, respondents working out in the field more than 50% of the time were more critical of the safety climate than the respondents spending more than 50% of their work hours in an office. Respondents (both employees and managers) working in the business area entrepreneur (construction), were also more critical of the safety climate than the other business areas (distribution, production, district heating and marketing). Results for the separate business areas showed that respondents working with operation, maintenance and construction were the most critical of the safety climate, which corresponded well with the respondents working out in the field. The results pointed to contact and communication between managers and employees and involvement of employees in safety related decisions as important for safety culture, in addition to clarification of roles and support for middle-managers.

Results from interviews and workshop showed that the energy sector is characterized by many different work tasks and a very diverse risk picture. The interviewees described risks associated with high and low voltage, working at heights, driving and securing cargo, working alongside roads with traffic, working in rough terrain, working with dangerous tools (e.g. chain saws, dynamite), loading with helicopters, etc. At the electrical power stations, there are also great mechanical forces which can pose a risk, and in emergency situations there may be risky work with clearing of forests, night work, and work in dangerous weather, such as storms and hurricanes. According to the middle-managers there was a strong focus on high voltage and the risk of electric shock, and the sector has carried out a lot of safety work to prevent such accidents. However, there has been less focus on many of the other risks.

Many employees in the Norwegian energy sector work out in the field, across large geographical distances, far away from their immediate managers. Managers and employees may also be situated at different locations. Hence, there is often a lack of daily face-to-face communication. The middle-managers also described a reluctance among employees to report observations, near misses, or accidents. The employees were reluctant to report both their own mistakes and those of their colleagues. Results from both the questionnaire survey and the interviews/workshop showed that there is a high level of 'risk acceptance' in the Norwegian energy sector. The employees seem to acknowledge that they work in a potentially dangerous profession, but at the same time seem to accept this risk as 'just part of the job'.

6 TRANSLATION PROCESS—IMPORTANT FACTORS

It proved to be very important to conduct the questionnaire survey and in-depth interviews in the Norwegian energy sector, before developing and implementing tools for improving safety culture. As previously mentioned, it is important to consider the unique interplay of the key dynamic features of the relevant sector in specific real-life contexts, before implementing a tool. Safety culture is embedded in social processes and practices, and cannot be assessed, analyzed or evaluated independently of its specific context (Le Coze 2013). According to Le Coze (2013), organizations need to implement certain functions in a coherent manner to ensure safety, however the implementation of these functions will be the result of a particular technological design, tasks, and structural features of organizations, in addition to cognitive, cultural and power issues at several nested layers of analysis. Gaining insight into the specific real-life context of the Norwegian energy sector provided important information that was used in the translation process to find the right fit between the idea/practice and the adopter.

The results from the study of the Norwegian energy sector showed that there are both similarities and differences between the construction and energy sectors. As previously mentioned, the Norwegian energy sector has in recent years experienced stagnation in their accidental injury rates, while other industry sectors (e.g. construction) have seen a decline in these rates. However, the construction industry is also one of the most injury-prone industries in both Denmark and Norway (Arbejdstilsynet 2015, Arbeidstilsynet 2015). A previous study, initiated by Energy Norway, concluded that the Norwegian energy sector has for many years been focused mainly on operations, and to a lesser extent on projects and developments. Moreover, the study found that the energy sector was characterized by a 'reactive' approach to risk and safety (DNV GL 2014).

The Norwegian energy sector is now entering a period of increased construction activity, and increasing use of entrepreneurs and sub-contractors. This means that the energy sector will face many of the same risks as the construction industry. In the construction industry, work is often performed at multiple job sites and the mix of contractors, trades, and workers changes as projects progress, which provides many challenges in implementing initiatives to promote safety and safety culture in general (Lehtola et al. 2008, Jeschke et al. 2017). This also applies to the energy sector. Fall accidents are some of the most frequent accidents in both sectors, and both sectors work with dangerous tools and machines.

The construction and energy sector are also different in other aspects. As pointed out previously, employees in the energy sector perform many different work tasks, and results from interviews and workshop showed that the energy sector is characterized by a very diverse risk picture. The energy sector is also characterized by temporary workplaces with frequent changes in risk situations. One of the most important differences is that many employees in the Norwegian energy sector are working out in the field (alone or two-and-two), far away (sometimes 100's of km) from their immediate managers, which results in a lack of daily face-to-face communication between managers and employees in the sector. The employees in the energy sector also work in rough terrain, and emergency situations lead to extra risky work tasks. Furthermore, the risk of electric shock from high or low voltage is specific for the energy sector. Based on these differences, it was necessary to change several of the elements of the original training program to better fit the specific challenges faced by the managers and employees in the energy sector.

In the original training program, a 22½ hour classroom program was developed by the project team and was carried out over five half-days (4½ hour per day), with two weeks of on-site training between training days, for a total program length of nine weeks. However, this was considered as too extensive by the representatives from the member organizations in Energy Norway. The 22½ hour program did not fit the work schedules of the Norwegian energy sector, and needed to be adapted. The new safety culture training program for the energy sector ended up consisting of an 8 hour classroom program carried out over two half-days (4 hours per day), with two weeks of on-site training between the training days.

In 2014, the board of Energy Norway adopted a Vision Zero related to accidents and injuries. The Zero Accident Vision (ZAV) is the ambition and commitment to create and ensure safe work and prevent all (serious) accidents in order to achieve safety excellence. This is a high ambition and it often gives rise to several misunderstandings that focus on ZAV as a 'goal' of zero accidents, rather than as a 'journey' and a 'process' of creating safe work (safety excellence) (Zwetsloot et al. 2017). Zwetsloot et al. (2017) developed a table which shows how ZAV differs from traditional safety strategies. In this way, ZAV can serve as a coherent framework for processes and practices that contribute to transforming the vision into measureable safety improvements. The table is not only of theoretical relevance, but can also be used to review existing safety policies—both at a company, sector and national level. Based on Energy Norway's adoption of Vision Zero, it was decided that the safety culture training program should include training in the understanding of ZAV, and how it differs from traditional safety strategies.

In general, the Norwegian and Danish labor regimes are almost identical, with only a few minor differences (Gooderham et al. 2011). Both countries have Working Environment Acts which specify obligations regarding health, safety, and environment for both managers and employees. However, the specific wording of the legislative texts is somewhat different in the two countries, and it was important in the translation process of the training program that the content of the program was made to fit the specific national labor regulations for the Norwegian energy sector. Likewise, examples from practical casework and role-play in the construction training program were adapted to relevant energy sector examples.

The results from the questionnaire survey and interviews also showed that there was a challenge in the Norwegian energy sector related to under-reporting of observations, near-misses, and accidents. Therefore, the representatives from Energy Norway expressed a need for a focus on developing a reporting culture and a just culture (Reason 1997) in the sector. Thus, the training program was adjusted to incorporate more information and exercises regarding these topics.

Finally, the managers and employees in the energy sector generally have a higher education level than in the construction industry; many are engineers and/or have a higher-level technical education. Managers and employees in the energy sector also speak a different 'professional language' than the managers and employees in the construction industry. The authors thus spent a significant amount of time discussing the language used in the training program with the representatives from Energy Norway and with HSE managers/coordinators from the member organizations. Many words used in the original version were unfamiliar to the representatives from the energy sector, and needed to be replaced to fit the specific real-life context of the current project.

7 CONCLUSIONS

The current research project resulted in a toolbox of safety measures that Energy Norway can use in their attempt to improve the safety culture in the Norwegian energy sector. The toolbox consists of a website with different brochures, leaflets, score sheets, playing cards, and the safety culture training program for middle-managers described in this paper. The leadership training program ended up being different in both form and content from the original Toolbox-training program which it was based on, as a result of the thorough translation process performed by the authors in cooperation with representatives from Energy Norway and their member organizations.

The research question addressed in this paper was: "What factors are important to consider when translating a safety culture training program from one industrial context to another?" During the translation process the authors found many important factors to consider in the specific context of the industry, e.g. national and industry-specific regulation, the technology used, work tasks, organization of work processes and practices, risk picture, education level, and the specific 'language' of the industry.

This study concludes that it is necessary to have thorough knowledge and understanding of the specific context before attempting to develop tools for improving safety culture. It is not sufficient to simply implement a tool developed for a similar organization or industry/sector, nor from another 'culture'. This provides support for Antonsen's (2009) argument against large 'one size fits all' safety culture programs.

Finally, the 'translation' process also emphasized the importance of 'research to practice' and 'knowledge transfer and exchange' (Van Eerd 2011), whereby researchers work in close cooperation with industry in adapting and developing OSH tools.

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The safety culture award competition in the Czech Republic and Slovakia

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ABSTRACT: The Safety Culture Award competition was organized by the VSB—Technical University Ostrava, The Faculty of Safety Engineering. The main goal of this activity was to assess the safety culture in manufacturing companies with more than 100 employees in the Czech Republic and Slovakia that applied for the competition. Its secondary goal was to share the best practices and to present proven safety culture enhancement tools.

1 INTRODUCTION

1.1 *Safety culture*

From the nuclear power industry, the safety culture was transferred also into other industries. It is closely related to the company culture and to the way its employees on all levels behave, including their approach to safety and health protection during work. The safety culture self-assessment and enhancement process described in the document *IAEA-TECDOC-1329 Guidance for use in the enhancement of safety culture* is intended mainly for nuclear facilities. But it may be very easily applied in other industrial companies as well. Taking into consideration that we are assessing a culture, one must keep in mind that it is not only about the way the safety system is set and applied, but it involves changes in human behavior, relationships, rituals, philosophy, and subconscious actions as well. These aspects are very hard to measure exactly but there are many characteristics that serve as indicators of the level of the safety culture within the given company. Comparison of these characteristics makes it possible to perform benchmarking inside of companies or among different enterprises.

1.2 *Overall information about competition and participants*

The Safety Culture Award competition was organized by the VSB—Technical University Ostrava, The Faculty of Safety Engineering. The main goal of this activity was to assess the safety culture in manufacturing companies with more than 100 employees in the Czech Republic and Slovakia that applied for the competition. Its secondary goal was to share the best practices and to present proven safety culture enhancement tools.

26 companies from different sphere of industry took part in Safety Culture Award 2016–2017.

- Automotive industry – 7 companies
- General engineering – 5 companies
- Heavy manufacturing – 3 companies
- Pharmaceutical production – 2 companies
- Electric supply – 2 companies
- Construction, cement production, food processing, chemical industry, refinery, mining and quarrying and light engineering were represented by one company.

19 companies were from the Czech Republic, 7 companies from Slovakia.

Size of enterprises:

- more than 1000 employees – 11 companies,
- 500–1000 employees – 4 companies,
- 100–500 employees – 11 companies.

The biggest company gives work to more than 3900 employees, the smallest to 130 employees.

2 METHODS

2.1 *System of assessment*

The Kirschstein & Partner methodology was used when assessing the level of the safety culture in individual companies. This methodology is based on the criteria founded in IAEA-TECDOC-1329 publication as well as on real knowledge and experience gained by the company over more than 30 years of its existence. Two levels were taken into consideration for the assessment—how the basic framework is set and the way of its implementation in practice. Conformity between documentation and real everyday life at work was very important. It was a three-round competition.

2.2 *The first round*

In the first round, questionnaires were distributed. The goal of the first round was to select the companies that achieved a higher level of safety culture. Assessment in this round was based on self-assessment in a form of a questionnaire, which was filled in by Safety Managers from the individual companies.

Questionnaire included 39 question. Different kind of questions were used: open—ended questions, contingency questions following up an open—ended question, closed—ended scaled questions and some closed—ended questions.

Examples: Do you have safety vison? If yes—describe it. What safety goals were set for 2015 and for 2016? Describe positive consequences when goals are reached. Will be any negative consequences if goals aren't fulfilled?

Basic criteria within the given areas were assessed.

Visions and goals—what is the given company's vision in the safety area, what are the goals set in the company and the way these goals are assessed, what are the positive/negative consequences in case the goals are/are not being fulfilled.

Organization and regulation—what are the basic safety rules set within the company, how is the cooperation with supplier companies addressed, what are the rules for visitors in the company, how is the safety department organized.

Leadership—how each level of management is participating in work in the safety area, how is the increase of employees' engagement ensured, how are the employees encouraged to submit suggestions for improvements in the safety area, and what actions are organized for the employees.

Risk assessment—the risk assessment system, participation of employees in the process of risks assessment, the way the employees are informed about the outcomes and the adopted measures, including their entry into practice, were assessed.

Trainings and safety talks—what types of trainings are implemented in the company, the level of line managers' involvement in education activities, what forms of education are being used, how is learning encouraged within the organization.

Safety controls and audits—what types of controls are performed, which areas are they targeting, how are the outcomes of the controls further processed, who is performing the controls, how much are the managers on different levels involved in the control activities.

Lessons learned from accidents and incidents—what was the accident rate development in past 3 years, what accidents are being monitored, what are the methods of searching for the root causes, how are the employees informed about the accidents, and how do they learn from them. What is the system for monitoring near misses, dangerous situations, and unsafe behavior, and how many near misses were reported.

The last criterion was a self-assessment in the area of safety culture, where, using the scale from 0% to 100%, the safety managers assessed the employees' participation and how they perceive the safety in the company.

On basis of the assessment of these questionnaires, 20 companies that proceeded into the second round were selected.

2.3 *The second round*

Assessment in the second round was covering the same areas as in the first round, but it was more profound and more detailed. Data from the questionnaires, findings from the documentation sent by the companies, and information acquired during the interviews with experts/safety managers were combined. Conformity between the documentation and the way the procedures are observed in practice was an important factor. This followed during the interviews with safety experts.

For each area, it was possible to earn a certain number of points, which were awarded on basis of the predefined criteria. All points earned in the second round were added up and served as a basis for the second-round ranking.

All companies advancing to the second round, basic information about where their strong points lie and suggestions on how to improve their weak points in order to have a guideline for further improvement.

2.4 *The third round*

Four companies assessed as the best were selected for the final round. During the Czech national OHS conference, representatives from these four companies presented their projects and specific tools for enhancement of the safety culture to the attending OHS professionals during a 20 minutes long panel discussion. Based on these presentations, OHS professionals at the conference determined the final ranking.

The important part of the assessment was not only what the individual companies presented, but also how they managed to engage and impress the attending professionals.

3 RESULTS

Based on these professionals' assessment, the final ranking was determined.

1. SLOVNAFT, a.s.—refinery, 2300 employees
2. Slovalco a.s.—aluminum production, heavy manufacturing, 490 employees

3. Zentiva, k.s.—pharmaceutical production, 650 employees
4. Tyco Fire & Safety Czech Republic s.r.o.—light engineering, 300 employees.

The maximum to be earned was 270 points in the second round. The best company earned 240 points, the poorest result was 159 points. An average value was 190.7 points, i.e. 71%. Companies earned the best scores in the organization and regulation area—an average score level was 80%. The poorest results appeared in the area of incident investigation and trainings, where the average score level of the companies was only 61%. Concerning the incident investigation, it showed that a passive information about the incidents mostly persists, as well as an insufficient determination of root cause, and search for the offender. The employees are not reporting near misses—either because they see no reason why, or because they fear a sanction. As for the trainings, a passive form persists, a large quantum of information is provided, the trainings are collective, organized once per year, and mostly are not targeted to the specific issues for the given post. Discussions about risks occurring at their specific workplaces involving the line employees are missing, as well as systematic active education.

All companies applied for the competition exceed the legislation requirements, they understand that safety is not an obstacle for efficiency and are looking for other possibilities of development in this area.

All companies advancing into the second round are companies with a foreign equity ownership, a long-term experience with improving the level of safety, and are using learning and information sharing across the corporation.

This competition gained publicity for the area of safety culture, awarded the companies that have a long-term record of safety level improvement, showed the benefits arising from practice, as well as concrete improvement tools, and served as an inspiration for all companies wishing to improve in this area.

The previous years, when similar events took place, showed that industry enterprises are ready to share their know-how and to actively make use of experience gained in other areas. After this event, a group of OHS professionals established a platform where they help each other with implementation of processes for efficient enhancement of OHS level and safety culture.

4 SUMMARY

The above-mentioned method cannot be taken as an exact methodology. It is based on empirical findings acquired by the Kirschstein & Partner company while working in this area, as well as on subjective approach of the evaluators in the finals. In case a wholly detailed evaluation would be required, then it would be necessary to visit company and see production, conduct structured interviews with the company employees. This was not feasible within the competition because of time and limited resources.

But it may be said that the above-mentioned methodology made it possible to compare the safety culture in companies from different industry areas that it supported and appreciated the efforts that companies are making in this area, and helped to share the best practices and to create OHS professionals networking.

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A model for managing OHS in Finnish vocational training and education provider organisations

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ABSTRACT: Finnish Vocational Education and Training (VET) providers face major challenges due to educational reform, economic pressures and a decrease in student numbers. This places an occupational burden on employees that may harm their health. Current school safety models cover Occupational Health and Safety (OHS) issues inadequately. However, VET providers have a variety of procedures to manage OHS. Hence, a management model is needed that highlights the organisational measures targeting OHS improvements. The aim of this study is to construct a conceptual model for managing the OHS of VET providers. Six large VET providers participated in the study. The model was constructed based on the OHS requirements and VET providers' needs, and it can be utilised in the educational sector to improve OHS management and related awareness. The model can be integrated into VET providers' existing OHS practices and management systems.

1 INTRODUCTION

In Finland, there are 165 vocational education and training (VET) providers involving about 250,000 students per year (Ministry of Education and Culture 2017a). VET providers are owned by a municipal federation, municipality, private company or state, and a single VET provider typically operates numerous vocational institutions across a large area covering several municipalities (FNBE 2011). Currently, VET providers are facing major challenges due to vocational educational reform, economic pressures, digitalisation and a decrease in student numbers among future age groups (HE 39/2017, Pirhonen 2014). VET providers must adjust their resources to future needs and requirements and carry out major organisational changes to identify new ways of managing education. At the same time, the personnel of VET providers encounter a mental burden due to significant workloads, uncertainty, workplace conflicts and the necessity to develop new ways of operating (Tappura 2017).

In previous years, the number of VET providers has decreased (Pirhonen 2014), and it will be further diminished in the future to accelerate the unification of VET providers and their establishments (HE 39/2017). This means VET providers will become larger and more multifaceted in their respective educational fields.

The personnel of VET providers typically include a principal, training and line managers, teachers, instructors and support service personnel, including student, catering, cleaning, maintenance and ICT services personnel. Moreover, students work under the supervision of a VET provider during their vocational education (FNBE 2011). In addition, service provider personnel may operate in VET workplaces under their supervision.

Developing occupational health and safety (OHS) is one way to improve performance and well-being in VET provider organisations. Improving OHS can contribute to better well-being and job satisfaction among employees, as well as decreased occupational injuries, ill health, sick leaves, resignations and early retirements, with reduced related costs and consequently improved performance (Aaltonen et al. 2006, Tappura et al. 2013). Adverse working conditions in the workplace are associated with job dissatisfaction and further sicknesses and absences (Böckerman & Ilmakunnas 2008). During times of economic austerity and the threat of downsizing, reduced job security may decrease absences in the short run, but cause negative health effects in the longer run (Bratberg & Monstad 2015).

In any case, the motivation behind the development of OHS should arise from ethical and legal objectives (EC 2011). Developing OHS is a good way to demonstrate to employees that the employer cares about their well-being. Moreover, developing OHS may contribute to the realisation of other VET providers' objectives, particularly regarding the quality of education, as well as of the health, safety and well-being of students. Nevertheless, studies on school safety often focus on student safety, but the OHS of the personnel of VET providers is inadequately considered (Lopez Arquillos et al. 2017). Thus, further research in this area is needed.

OHS can also be seen as a part of corporate security management (Confederation of Finnish Industries 2017), which depends on the organisation's field of operation, strategy and operating environment (Lanne 2007). According to the Finnish definition of corporate security, core elements of corporate security includes (Confederation of Finnish Industries 2016):

- Personal security
- Facility security
- Rescue security
- Security of production and operations
- Environmental safety
- Information security
- Malpractice, crime and deviation control
- Emergency planning and crisis management
- OHS

According to Lanne's (2007) study, more cooperation and interaction are needed between all the security sectors and the people responsible for the different sectors. Active cooperation among top management, OHS personnel, line managers and employees can contribute to the organisation, goal-setting and decision-making of corporate security management. In Lanne's (2007) study, functional teams, the active role of individuals who connect different functions, employees' wide participation and active daily communication were emphasised in relation to cooperation. Regarding employees, they typically participated in aspects of occupational safety and rescue operations within the organisation.

VET providers operate under both education and OHS regulations (FNAE 2017, 630/1998, 738/2002). School safety is often defined as a combination of the physical, psychological, social and pedagogical safety of students (see Fig. 1, FNAE 2017), and vocational students have a right to a safe learning environment (630/1998). Hence, OHS issues are addressed inadequately in the current school safety model.

Moreover, VET providers have a regulatory obligation to provide a healthy and safe workplace so far as it is reasonably practicable (738/2002). Establishing an OHS culture with effective OHS processes helps in meeting the duty of care (Tappura et al. 2017, WorkSafe Victoria 2015). Hence, OHS issues are under the responsibility of management in VET provider organisations. The management of OHS can be integrated into existing management processes and development, rather than through developing separate procedures (EC 2016). Moreover, OHS management frameworks (such as OHSAS 18001:2007) can be utilised in developing the systematic management of OHS.

In Finnish VET provider organisations, OHS is often developed via projects with limited resources and competence and from students' perspective during on-the-job learning (Tappura 2014, 2012). However, the systematic development of employees' OHS is an employer responsibility, and the Finnish Occupational Safety and Health Act (738/2002) considers VET providers as employers. The Act applies to employees, students, service providers and other workers working under the VET provider's supervision. Moreover, developing VET providers' OHS culture, as well as employees' health, safety and well-being influences the safety and well-being of the students, as well.

Figure 1. The sections of school safety (FNAE 2017).

According to OHS regulations (738/2002), to manage OHS and to take care of the physical and mental health of employees, employers shall have a policy for action to promote safety and health and to maintain their employees' working capacity. The OHS policy must incorporate the need for working condition developments and the impacts of working environment factors on the employees. The policy and related OHS objectives must be considered in workplace planning and development. Moreover, the employer shall systematically analyse the hazards and risk factors caused by the work (that is, risk assessment) and eliminate or diminish the risks at work. Risk assessment must be built on a knowledge base, and available information on accidents, occupational diseases or work-related illnesses, hazardous incidents and other defects must be considered.

In Finnish educational provider organisations, the occupational burden generally arises from a role overload and constant interruptions, indoor air problems in school buildings, harassment or other inappropriate treatment and the threat of violence by students or their guardians (AVI 2015). As for teachers in general, role overload has been found to be one of the major and most pervasive OHS stressors (Austin et al. 2005, Boyle 1995, Pithers & Fogarty 1995). Previous interventions to overcome

OHS stressors in the educational sector have often focused on individual coping strategies and stress management training (e.g. Austin et al. 2005, Dewe 1985, Griffith et al. 1999, Timmerman et al. 1997, Seidman & Zager 1991). According to Kuoppala et al.'s (2008) review, previous research suggests the important role of leadership in employee job satisfaction, job well-being, sickness absences and disability pensions. Thus, work-related interventions can prevent disability and sickness absenteeism (Martimo et al. 2007).

According to Launis & Koli (2005), OHS risks and problems are largely studied in the educational sector, but the means to control the risks are rarely identified and developed as a part of organisational development. Moreover, the problems related to organisational changes and new challenges are often associated with employees' inadequate competence or single stress factors in the organisation. However, organisational-level solutions are needed to improve the workflow and well-being of employees. Hence, this study emphasises the organisational measures needed to reduce occupational injuries and ill health among personnel of VET provider organisations.

The purpose of this study is to construct a conceptual model for the systematic management of the OHS of VET providers. The model consists of organisational measures targeting improvements in work ability and OHS performance (for example, reducing occupational injuries and ill health) at the organisational level. This study does not explore the employees' individual resources or coping measures, as they are outside the scope of this study. In addition to the personnel of VET providers, prevention focus indirectly influences the OHS of students, as well. However, students are not the focus of this study.

2 MATERIALS AND METHODS

This study employed qualitative (Denzin & Lincoln 2011) and constructive (Kasanen et al. 1993) research approaches due to the contextual and descriptive nature of the study. Six large VET providers with 3,300 full-time employees in total participated in the study. The constructive research approach was applied in the design of the conceptual model for managing the OHS of VET providers. The constructive research phases (setting of requirements, construction of alternative solutions and validation of the constructions) (Kasanen et al. 1993) were followed to an extent appropriate for the purpose of this study. The constructive approach typically applies goal-directed problem solving through the construction of a practical solution, which is herein based on the VET providers' needs. The model is based on both existing knowledge and the heuristic research process.

The construction began with the definition of requirements based on OHS regulations and the appropriate literature. In the second phase, the organisational OHS procedures used by the participating organisations were collected by an OHS expert (n = 6) and through personnel interviews (n = 59). The interviewees represented all personnel groups, including teachers, support services personnel, managers, principals and OHS representatives. In the third phase, the participating organisations developed their procedures further and presented them to other parties in five workshops. In the fourth phase, based on the previous phases, the researcher drafted the preliminary OHS management model. In the fifth phase, the draft was then presented in a workshop and it was validated by OHS professionals of the participating organisations, whose feedback was considered as the model was developed further. Finally, the research contribution of the model was presented and its final usefulness was evaluated.

3 RESULTS

The conceptual model for managing the OHS of VET providers is based on the Finnish concept of corporate security, as well as on the concept of school safety. The requirements for the model were defined based on OHS regulations, the literature and the participating VET providers' views. As a background, the concept of VET provider safety was defined as a combination of school security, student safety and well-being and employee safety and well-being (see Fig. 2). According to the concept of VET provider safety, OHS is seen as a part of school safety, emphasising the physical and mental health and safety of employees and students when working under the supervision of VET providers. The responsibility and commitment of managers, employees and students to OHS were highlighted as important factors in VET providers' safety.

The major objectives of a VET provider, including OHS objectives, are based on the strategic planning and quality management of VET providers VET providers gather OHS background data and indicators, which are used in developing OHS. The OHS input data typically consist of the following information:

- Results of former risk assessments
- Injury statistics
- Occupational disease cases
- Absence rate due to sickness
- Reports of deviations
- Reports of dangerous situations/near misses
- Reports of workplace surveys
- Results of the occupational hygiene measurement
- Ergonomics mapping
- Results of audits and safety walks
- Workplace tidiness index

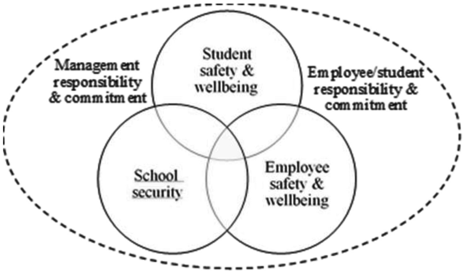

Figure 2. VET providers' definition for school safety.

Based on the OHS data and other information from the work environment, risk assessments were carried out to analyse systematically the risk factors of the work environment. The risks and deviations were either eliminated directly or corrective actions were planned with other development action, depending on the risk assessment.

The OHS policy of VET providers is based on indicators and risk assessments and it was integrated into the strategic planning of VET providers. The OHS policy defines the principles and objectives for OHS promotion, as one VET provider has defined: 'We take care about the well-being of the students and employees. The learning and working environments are safe and healthy. We prevent poor health, injuries and other harm by minimising dangerous situations.'

To achieve the OHS objectives and to control risks, VET providers have a variety of OHS procedures (see Table 1). The most common procedures to manage OHS were the OHS activity plan, health care plan, regular evacuation exercises, safety walks and internal safety audits. OHS responsibilities were defined typically and the persons responsible for the safety of certain agencies, as well as related teams were nominated typically. OHS training was arranged, such as OHS card training and training for threatening situations. One of the VET providers had a certified OHSAS management system. During the study, the participating VET providers shared their experiences and developed the OHS procedures further.

According to the results of the interviews, the employees acknowledged the availability, quality and sufficiency of the OHS procedures. Moreover, they perceived that the OHS representatives were available for help when needed. They did not call for more OHS procedures. However, they called for a more effective and coherent execution of the procedures across the VET provider organisations. Some interviewees were unaware of the level of OHS cooperation, particularly if have not had injuries or other OHS issues themselves. They called for more information about OHS cooperation and realised OHS activities. The OHS procedures were executed by the VET provider personnel typically. The students participated in relevant procedures, such as risk assessments, evacuation exercises and safety walks when they were carried out in the practical learning environment (e.g. laboratory or construction site).

Based on the previous phases, the conceptual model for managing OHS in VET provider organisations was constructed (Fig. 3). The model is

Table 1. OHS procedures in VET provider organisations.

OHS procedure
OHS activity plan
Occupational health care plan
Definition of OHS responsibilities
Top management safety group
Safety groups of the campus or building
Safety folder and instructions
Workplace surveys
Risk assessments
Rescue plans
Regular evacuation exercises
OHS introduction
Introduction of external actors
Regular OHS training
Chemicals register and safety data sheet folder
Machine safety insructions
Procedure for indoor air problem resolution
Safety notices and near-miss reports processing
Elmeri+ workplace observation method
5S workplace organization method
Construction site safety audits
OHS audits
Safety walks
Procedure for psychosocial risk control
Procedure for threatening and violent situations
Early support procedure
Rules for appropriate work behavior
Well-being development workshops
Stress analysis and control workshops
OHS campaigns and themes in communication

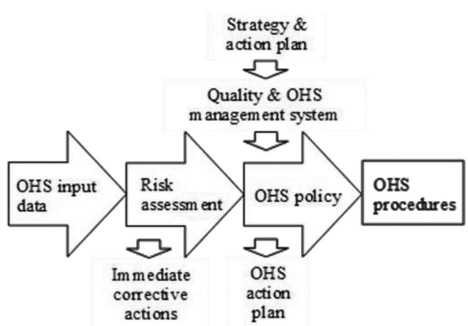

Figure 3. The conceptual model for managing OHS in VET provider organisations.

based on the strategic planning and quality management of VET providers. At the same time, the model takes OHS requirements and development needs into account.

The workshop participants evaluated that the model is suitable for its purpose, as it is illustrative and compiles the major OHS procedures in one repository. Hence, it helps in communicating the OHS procedures to employees.

4 DISCUSSION

This article described how VET provider organisations applied organisational measures in managing the OHS and work abilities of the employees. The current study aimed to develop a conceptual model for managing OHS that can be incorporated as an integrated part of strategic management into VET provider organisations (EC 2016). The model focuses on OHS, which can be seen as one part of the corporate security (Confederation of Finnish Industries 2016) of VET providers. The sections of corporate security overlap partly; for example, the risk assessments can incorporate several sectors of corporate security in a single risk assessment (Lanne 2007).

In addition, OHS can be is seen as a part of school safety (FNAE 2017), emphasising the physical and mental health and safety of the employees and students when they work under the supervision of VET providers (738/2002). Nevertheless, different definitions of school safety overlap and hence, accurate segregation between the definitions or contents cannot be achieved. Rather, an overall consideration of different perspectives and their connections should be adopted.

In constructing the model, the preliminary requirements were defined based on the OHS regulations, previous literature and VET providers' needs. The model was complemented with the OHS procedures based on the interviews in VET provider organisations. The model was then reviewed in a workshop of the OHS professionals of VET providers, and the final model was constructed based on the review. The model consists of input OHS data, risk assessments, OHS policy and action plans and OHS procedures. The model was based on the practical needs and problems of VET providers and was validated in practice by the participating six large VET provider organisations. Hence, the conceptual model can be considered valid for the purpose of this study.

The model emphasises risk assessments as an essential element of managing OHS. The risk assessments state the major OHS risks and the basis for both short- and long-term OHS development needs and activities. Different corporate security sectors can be included in the risk assessments, and risk assessments can provide means to increase cooperation among the sectors (Lanne 2007).

The OHS policy is an essential document for OHS promotion, as it set the OHS objectives and demand for development activities in the future. The OHS policy compiles the OHS objectives derived from the strategic objectives and development needs found in the risk assessments into an activity plan that should be in line with other development plans, such as the occupational health care plan.

The model includes the OHS procedures to control the physical and mental safety and health of employees. VET providers typically had many procedures to improve OHS. One of the VET providers has a certified OHSAS system, meaning it has an appropriate OHS policy, procedures and protocols to ensure it is a safety-conscious organisation (OHSAS 18001:2007). However, in some VET provider organisations, these procedures were somewhat disconnected and the overall picture of how to actually improve OHS was partly unclear. In the least, the OHS procedures could be better coordinated and communicated to employees.

The conceptual model aimed to provide a simple framework and practical examples of OHS procedures for managing OHS within VET provider organisations. The key contribution of this study is the model for systematic OHS management and understanding of how OHS management can be integrated into the VET provider's management system. The model can be utilised alongside other OHS management frameworks (such as OHSAS 18001:2007) to emphasise the strategic viewpoint of OHS issues.

The model serves as a tool for managers responsible for OHS. OHS professionals can support managers by developing, implementing and reporting the model and related procedures. The model can be integrated into the VET provider's existing OHS practices and management system. The identification of organisational OHS procedures and good practices can be utilised in the educational sector to improve OHS management and related awareness. However, organisation-specific modifications and emphasis must be recognised when applying the results. The results of the study help educational organisations in improving the OHS and well-being of employees and hence enables them to focus on performance during difficult times.

5 CONCLUSIONS

This study constructed a conceptual model for managing OHS to be incorporated in the strategic management of VET provider organisations. The model consists of input OHS data, risk assessments, OHS policy and development activities and OHS procedures. The practical implication of the study is the provision of a simple framework and examples of the OHS procedures for the systematic management of OHS in VET provider organisations. The model helps managers to handle OHS risks and utilise related control measures.

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Promoting a positive safety culture in the maritime industry by applying the Safety-II perspective

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ABSTRACT: One of the core ideas of the maritime safety management system, the ISM code, has been to create a just culture through open incident reporting. However, perhaps due to a blame culture, incidents are poorly reported in maritime. The traditional approach (Safety-I) focuses on reactive responses and on eliminating the causes of human failures, whereas the new approach (Safety-II) considers humans a resource for successful performance. We tested a Human Factors (HF) tool in Finnish maritime. This tool is based on the Safety-II perspective: it focuses on successes and strives to understand human performance at the individual-, work-, group- and organizational level. The maritime organizations had no such HF tool in use. The tool was regarded as an opportunity to involve the operative personnel in reporting and analysing incidents, and understanding human performance. Use of the HF tool could help root a positive safety culture in the maritime industry.

Keywords: Maritime Safety Culture; Human Factors; Incident Reporting; The ISM Code

1 BACKGROUND

1.1 *Promoting safety culture through a safety management system in maritime*

Safety management systems (SMS) have been widely used in safety-critical industries such as the aviation and nuclear power industry. One of the core ideas of safety management systems has been the creation of a just culture, by using incident reporting schemes to detect weaknesses in the system and implement corrective actions to improve work processes and safety. The maritime industry is also considered a safety-critical industry. The ISM Code is the response of the maritime industry to incident reporting, and strictly requires that incidents are reported and corrective actions are implemented (IMO 1995/2014). However, several studies in maritime have found that one of the most common ISM-related deficiencies is the lack of reporting non-conformities, accidents and hazardous occurrences, as the Code requires (Bhattacharya 2009, Lappalainen 2016). Previous studies concerning incident reporting have indicated that one reason for poor reporting may also be that a blame culture still exists (Bhattacharya 2009, Oltedal 2011, Lappalainen 2016, Teperi et al. 2017b).

1.2 *Safety paradigm shift from Safety-I to Safety-II by applying Human Factors*

The traditional approach to incident reporting can be characterized by the concept of Safety-I, which focuses on reactive responses and strives to improve safety through eliminating the causes of human failures or errors: individuals are regarded as a source of errors. The concept of Safety-II, in contrast, considers humans a resource of successful performance, and focuses on factors that create and maintain safety. (Hollnagel 2014, Schröder-Hinrichs et al. 2015).

Despite active discussion of safety science, no practical tools exist to demonstrate how to put Safety-II into practice in systems and organizations or at the floor level of workplaces.

In this study, we applied a Human Factors (HF) framework as a facilitator and intermediator for promoting a positive safety culture. We operationalized an HF framework as an HF tool, which had already been designed, modified and applied in other safety-critical fields (Teperi 2012 in ATM, Teperi et al. 2017a in the nuclear industry). We particularly wanted to study whether the HF tool had potential for facilitating the implementation of Safety-II thinking in maritime, while in the previous studies (e.g. Teperi et al., 2015; 2017a), it offered wider understanding of humans as a resource behind incidents and highlighted successes in handling incidents in the earlier studies.

As an object of the study, we used maritime, which has been recognized as having solid international safety management regulations and procedures (Schröder-Hinrichs et al. 2015, Lappalainen 2016), but also weaknesses in open incident reporting (Teperi et al. 2017b).

1.3 *Human factors as a way of applying Safety-II thinking*

The HF framework was chosen for this study, because as a discipline, it currently regards human performance as a key enabler in the creation of safety (Hollnagel 2014, Reason 2008, Hale & Hovden 1998). Thus, HF facilitates the promotion of a positive safety culture.

HF aims to apply knowledge on human behaviour (human capabilities and limitations) in the design of systems, and to maintain the efficiency, safety and well-being of those working within it (FAA 2005, Kirwan 2001, Wilson 2000). It also refers to individual, work, group and organizational factors that can either support or harm the functioning of systems (Teperi 2012). Awareness of and competence in HF is crucial, especially in complex and safety critical fields such as maritime, which have the potential of risks and accidents due to the complexity, dynamicity and uncertainty of their systems (Norros 2004, Vicente 1997). HF has long been recognized as an essential factor behind incidents and accidents (Reason 1997, 2008).

SMSs have their roots in three disciplines: systems engineering, HF and business management (Maurino 2017) and have evolved from compliance-based SMS to performance-based SMS, focusing on resilience (Kelly 2017, Lofquist 2017) and requiring wide co-operation among system partners. Fragmentation however, presents an obstacle for implementing SMS (Lappalainen 2017). The field of HF has evolved from technical and risk-based thinking to focusing more on organizational factors, safety culture and safety management systems (Teperi 2012, Hollnagel, 2006, Hale & Hovden 1998).

However, it seems that SMS are implemented as compliance-based systems in maritime, representing a technical-authoritarian view of SMS, and focus on compliance with regulations and norms, followed up by audits. Furthermore, support of human performance plays a weaker role in SMS (Teperi et al. 2017b). Several researchers feel that a blame culture still exists in maritime (Anderson 2003, Ek & Akselsson 2005, Bhattacharya 2009).

2 METHODS

2.1 *Background and application of the HF tool*

The HF tool aims to determine the issues in human actions or behaviour (i.e. human factors) that either weaken or improve the safety of the reported cases (Teperi 2012, Teperi et al. 2015). The HF tool has 37 different detailed items that have positive or negative impacts on safety, and are grouped into four levels (individual, work, group and organizational HF). Its items concern, for example, situational awareness, equipment, communication and organizational decision-making. These have all been found to be relevant background factors in mishaps in safety-critical work (e.g. Reason 1997, Wiegmann & Shappell 2002, Kirwan 2003) (Fig. 1).

The HF tool was originally designed in 2008 to be used in analysing human causal factors in incident reporting by safety critical air traffic management (ATM) personnel, as part of safety management (Teperi 2012, Teperi et al. 2015). Later, the HF tool was modified for nuclear industry purposes (Teperi et al. 2017a) and for maritime (Teperi & Puro 2017).

In aviation and in the nuclear industry, we found that the HF tool helped personnel learn to understand the background factors of the incidents that occurred in their own work. It also offered a more accurate picture of the analysed events than previously, including successes, which offered a new perspective to the study participants. The HF tool was also regarded as visual, user-friendly, clear, and easy to use (Teperi et al. 2015, 2017a); and useful for investigation, training and self-evaluation, and monitoring safety trends (Teperi et al. 2017a). The HF tool use has also been used in an education department, a rescue and firefighting department and an energy production unit of a

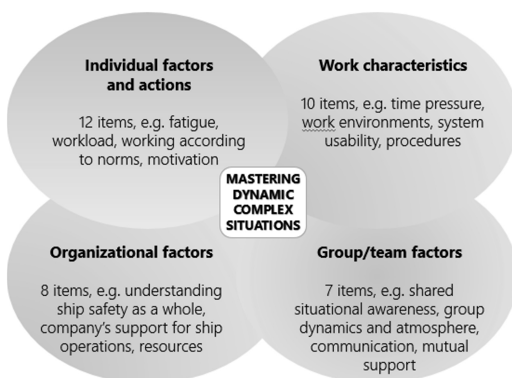

Figure 1. HF tool: basic idea and contents (maritime HF tool in detail in Teperi & Puro 2017).

city organization, as part of safety management training and HR processes (Teperi 2016).

A workshop to modify the HF tool for maritime purposes was held by the two authors (HF expert and maritime safety culture expert) of this paper in 1/2016, after which the HF tool for maritime purposes was published (Teperi & Puro 2017). In this study, the maritime HF tool was introduced to maritime personnel and tested in the workshop.

The contents of the HF tool corresponds to existing HF tools such as the HERA-Janus method (Shorrock & Kirwan 2002, HERA Janus 2003) and HFCAS (Wiegmann & Shappell 2003).

Based on our studies described above, we argue that our HF tool represents Safety-II thinking, which highlights humans as sources of success, tries to understand variance in human performance, and aims to determine the background factors that lead to successes or failures in human performance.

2.2 *Materials and methods of the study*

Eight Finnish maritime organizations participated in this study in 2016: three shipping companies, the Transport Safety Agency, the Administrative Agency, the Passenger Ship Association, Vessel Traffic Services (VTS Centre) and the Department of Occupational Safety and Health of the Finnish Ministry of Social Affairs and Health.

In Phase 1, we interviewed 29 study participants in 18 interviews; 17 individually and 12 in group interviews (5 in one and 7 in the other group interview) on the topic of HF in work and safety. We asked:

- How do you define HF?
- How do see this in your work?
- How do you handle this on board your ship?

Phase 2 consisted of the HF tool workshop, in which participants were trained in the HF tool and tested it in four maritime cases (e.g. mixed crew, radar offline failure). We also collected intervention material.

In Phase 3, at the end of the workshop, four small group interviews (3–4 participants in each small group) were conducted. The detailed interview questions were:

- What did you or your small group think of the HF tool? What did you observe while testing it?
- Do you already have a similar kind of HF tool in use? What? Since when?
- In which cases would you utilize it in your organization (e.g. SMS, occupational health and safety, HR)? What uses would the HF tool have? In which cases or uses would it not be suitable? Why? What are the possible weaknesses of the HF tool in your organization? What could its strengths be in your organization?

Table 1. Material, methods and themes used in different phases (1–3) of this study.

	Theme/topic	Material, study participants	Method
Phase 1	Conceptions of HF	Unit and safety managers, maritime and OHS inspectors, operative personnel (347 pages transcribed text)	Individual interviews (17, n = 12) Group interviews (2, n = 12)
Phase 2	Training and testing of HF tool	Workshop materials, use of HF tool*	One day workshop, testing HF tool (n = 13)
Phase 3	User experiences of HF tool	Unit and safety managers, maritime and OHS inspectors (40 pages transcribed text)	Group interview at end of workshop (4, n = 13)

The study material, methods and themes are summarized (Table 1).

The interviews were conducted face to face, and mainly took place at the actors' workplaces (office/offshore).

2.3 *Aim of the study*

We studied whether applying an HF tool that focuses on the Safety-II perspective can promote a positive safety culture in the maritime industry. First, we wanted to know how the interviewees define HF, to see their development phases in HF thinking, and to determine any needs to promote the Safety-II perspective in maritime. Second, we tested the HF tool, and asked the study participants for proposals for its use and their user experiences. Finally, we summarized the study findings, and compared them to the principles of Safety-II thinking, to see whether the conceptions of the HF tool use were congruent with the ideas of Safety-II and if the tool would facilitate the promotion of a positive safety culture.

The maritime industry has had weaknesses in openly collecting safety data, which is the core idea in the creation of a just culture, and for improving the safety level in safety critical fields (Maurino, 2017; Dekker, 2002; 2007).

The detailed research questions of the study were:

1. How did the maritime actors define HF?
2. What were their proposals for the use of the HF tool in their own organization?
3. What did the users think of the HF tool (strengths and weaknesses)?

Based on the results of these three research questions, we determined and summarized the prerequisites and development needs of the HF tool for promoting a positive safety culture in the maritime industry.

3 RESULTS

3.1 *Definitions of HF in maritime organizations*

We asked the interviewees about their conceptions of human factors, and these are summarised in Table 2. The numbers in the table columns represent the number of answers: how many respondents gave this type of conception in their answer.

As the frequencies of the different conceptions in Table 1 reflect, conceptions of HF are mainly error—and individual-based.

HF are described, for example, as errors, misunderstandings and problems in relations or communication; "It is some kind of mistake, which happens unintentionally." Eight interviewees mentioned fatigue in their conception of HF.

Only one of the interviewees mentioned a positive aspect of human factor.

Only six interviewees out of 29 offered a wider perspective to HF. One interviewee defined HF in a wide manner, even reaching system wide maritime, also concerning authorities.

Table 2. Definitions of HF.

Type of conception	Individual[1]	Group[2]
Human factor = human error (15)	*13*	*13*
HF are described as behaviours: errors, misunderstandings, lapses of memory, communication problems.		
Human factor = individual's actions and characteristics (10)	*8*	*2*
Individual's actions, working according to instructions, individuals' decision-making, competence, motivation, fatigue		
Human factor = wider factors than individual based conceptions (6)	*6*	*0*
Characteristics of work (usability of devices, working conditions, introduction), group-level factors, organization level factors.		

[1] Individual interviews (n = 17).
[2] Group interviews (n = 5, n = 7).

3.2 *Proposals for future use of HF tool in maritime organizations according to group interviews*

Study participants' views regarding the HF tool's future use were elicited in the group interview at the end of the workshop, after testing the tool. Interviewees mentioned many different ways of using the HF tool in the future:

- as a tool for incident/accident investigation (the most mentioned purpose—mentioned in four group discussions)
- as a tool for proactive safety/risk assessment or tool for work planning (mentioned in three group discussion)
- as a self-evaluation tool, especially after occurrences/problems as one part of reporting occurrences (mentioned in one group discussion)

Table 3. Users' experiences of the HF tool, strengths and weaknesses (in how many group discussions mentioned).

Strengths of using the HF tool • Higher quality of investigation: HF tool helps investigate and broadens one's thinking regarding the background factors of incidents. (4) • Systematic use of HF tool and classification of HF tool items offers trendlines and helps identify corrective actions. (2) • Clear, simple tool (1) • Coverage of tool (1) • Excellent tool for teamwork (1) • Using the HF tool provides a positive perspective (1) • Helps understand own actions (1) • Would standardize investigation practice of investigators (1) • Would provide new type of safety information for authorities (traditionally technical-oriented) (1) • Suitable tool for HR and team conflict issues (1)
Weaknesses of using the HF tool • Resistance to change hinders implementation of new tools and practices in maritime) (3) • Difficult to bring up personal issues (for example, fatigue, motivation, health) (3) • Takes more time (at least at the beginning) and is difficult to use. Contains too much information. (2) • Using the HF tool requires familiarization (2) • Tool does not instruct how to define corrective actions (2) • Technical restrictions of incident reporting system (1) • Poor incident reporting culture in maritime organisations (1) • Varying size of items (one is easier to assess than the other) (1) • Tool does not prioritize different items or help in choosing main factors (1) • The name of the tool could better point to investigation (1) • Risk of using "favourite items" (1)

- as a tool for annual audit/master review (mentioned in one group discussion)
- as a tool for group development debate (mentioned in one group discussion)
- as a tool for human resources and team co-operation/conflict issues (mentioned in one group discussion).

The maritime organizations had no similar kind of HF tool in use for incident reporting and analysis.

3.3 *Users' experiences of the HF tool*

Workshop participants' conceptions of using the HF tool and its strengths and weaknesses, revealed in the interviews, are summarized in Table 3.

The widely shared conception of the workshop participants was that using the HF tool in incident investigations would lead to higher quality investigations: the HF tool broadens thinking to consider the background factors, helps identify corrective actions and is an excellent tool for teamwork. Resistance to change, difficulties bringing up personal issues, time, and training needs were mostly mentioned as weaknesses of the HF tool use.

4 CONCLUSIONS

We studied whether applying an HF tool that has represented the principles of Safety-II perspective in the earlier studies (Teperi et al., 2015; Teperi et al., 2017a), can promote a positive safety culture in the maritime industry, and tried to determine the prerequisites and development needs of the HF tool for promoting a positive safety culture in the maritime industry.

We first wanted to know how interviewees define HF, to see their development phases in HF thinking and whether the promotion of the Safety-II perspective is needed in maritime. We found that conceptions regarding HF were mostly individual and error based in maritime, representing Safety-I thinking, which may be regarded as one of the main hindrances of open incident reporting and analysis, because of fear of blaming (e.g. Teperi et al. 2017a). To improve mariners' HF conceptions, awareness and competence of HF should be improved, to build an accurate picture of HF not only as an individual phenomenon, but also as a work, group and organizational factor, that can either support or hinder the success of individuals in their work and in maintaining safety. HF coaching could more clearly focus on success factors, which help in maintaining safety (e.g. Reason 2008, Hollnagel 2014).

Our results revealed a need for Safety-II thinking and promoting a positive safety culture in maritime.

Secondly, we tested the HF tool that was modified for maritime purposes (in Teperi & Puro 2017), and asked the study participants for proposals for its use. They found several uses for the HF tool. Mostly, it was regarded as useful for incident reporting and analysis, especially due to its wide scope in understanding the individual-, work-, group- and organizational factors behind incidents; incidents are not due to individual errors, but mainly circumstances which either support or hinder operative personnel from succeeding in their work. They also saw the tool as providing an opportunity for operative personnel to participate themselves in analysing incidents.

The HF tool was also regarded as useful as a tool for proactive safety and risk assessment or for work planning, as a self-evaluation tool especially after occurrences/problems, as part of reporting occurrences, as a tool for annual master reviews, as a tool for group development debate, and as a tool for human resources, team co-operation and conflict issues. All these uses could promote the creation of a positive safety culture and be a way to increase participative safety management, which previous studies have also found to be important (e.g. Teperi & Puro 2017, Teperi et al. 2017b, Guldenmund 2010, Antonsen, 2008). The Safety-II perspective focuses on proactive safety management practices, and issues that maintain safety as well as trying to understand the circumstances behind human performance (Schröder-Hinrichs et al. 2015, Hollnagel 2014). Reason (2008) has also broadened his human error model ('Swiss Cheese' from 1990's; Reason 1997) to handle humans as heroes in system vulnerabilities. The framework of resilience engineering (Hollnagel et al. 2006, Weick & Sutcliffe 2007) stresses these same ideas.

Thirdly, we asked the interviewees for their user experiences of the HF tool in order to learn of the strengths and weaknesses. The main strengths of the HF tool were that it would offer higher quality of investigation and would help safety analysts investigate and broaden their thinking to take into account the background factors of incidents. The systematic use of the HF tool and classification of HF tool items was also believed to offer trendlines and to help identify corrective actions. The tool was regarded as clear and simple to use, with good coverage of the varying background factors, and good for providing a positive perspective of safety. According to the study participants, the HF tool helped them to understand their own actions, would help standardize investigators' practices, and would provide new types of safety information for authorities, which is traditionally technical-oriented. It was also regarded as suitable for HR and team conflict issues.

As weaknesses, study participants saw that general resistance to change hinders the implementation of new tools and practices in maritime, and that this would cause problems in bringing up personal issues (for example items concerning fatigue, motivation, health at the HF tool) while using the tool. Using the HF tool would also take more time (at least at the beginning) and in its current form contains too much information. Using the HF tool requires familiarization. Currently, use of the HF tool does not include instruction for defining corrective actions and some technical restrictions prevent including the HF tool in the current incident reporting system. Moreover, the poor incident reporting culture in maritime organizations, the varying size of the items (one is easier to assess than the other), the fact that the tool does not prioritize different items or help choose the main factors were mentioned as hindrances in the use of the tool.

The maritime organizations (shipping companies, authorities, educational parties) play a role in increasing HF awareness, which is a key factor in promoting safety. In practice, maritime organizations should be instructed properly in the use of the HF tool in order for implementation to be accurate, and to enable its full use.

Researchers and safety experts would need a proper, deeper understanding of maritime safety culture to find the best ways in which to implement the tool in maritime.

Finally, the HF tool should be developed and further modified. To have a lighter version for the shipping companies and the authorities, the tool would need to be digitalized, and some of the items summarized. Thus, the HF tool would better serve maritime purposes and made into an automatic part of the SMS, as was done in ATM (Teperi 2012).

To summarize, there is a clear need for Safety-II thinking in maritime, to promote positive safety management and safety culture. The HF tool supported the aims of the Safety-II perspective, as described by Hollnagel (2014) and Schröder-Hinrichs et al. (2015) by, for example highlighting the variance and successes in human performance and the possibility of understanding local knowledge and participative safety management.

Focusing on positive human factors provided by the HF tool and understanding humans as a resource of successful performance motivated and encouraged the study participants. As highlighted in Safety-II thinking, using the HF tool could promote the rooting of a positive safety culture in the maritime industry.

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Applying Pareto approach in the prevention of occupational accidents in cement industry—a case study at Holcim Vietnam

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ABSTRACT: Cement industry is one of the industries containing various hazards and high risk activities which can potentially lead to occupational accidents. The objectives of this research were to (1) analyze the high risk activities in cement manufacturing which potentially lead to occupational accidents; (2) use the Pareto principle in order to define key hazards which were analyzed based on specific incidents and hazards in Holcim Vietnam Cement Company; (3) recommend appropriate approaches to prevent occupational accidents in cement industry. In this research, all accidents, near-misses and hazards statistics in a six-year period from 2011 to 2016 at one cement plant and three cement grinding plants belong to Holcim Vietnam Cement Company were collected, analyzed and defined key hazard categories based on Pareto approach. The Pareto charts were used to show the hazard categories accounted for 80 percent in the total hazards which were occurred and mainly caused occupational accidents in cement industry. Finally, the control approaches of the critical hazards in cement industry were recommended by applying risk management process.

1 INTRODUCTION

Cement industry is one of the high risk industries (Cankaya, 2015) in which workers are usually exposed to variable hazardous factors which caused major accidents. The main hazardous factors in cement industry include vehicles operations, working at height, working in confined spaces, moving machines and electricity. The consequences of the occupational accidents relating to these factors are usually serious such as fatalities, permanent injuries and lost time injuries.

In order to gain the ability to reduce the accident rate in cement industry, the hazardous factors must be identified and controlled properly. One of the methods in which the hazardous factors can be found by analyzing the root causes of incidents included occupational accidents, near-miss events and dangerous occurrences. Then the Pareto principle was applied to identify the main causes of these incidents. The elimination of these critical causes which will significantly improve working condition and minimize occupational accidents in cement industry. According to the Pareto principle, the key hazard categories accounted for 80 percent in the total of causes of historical incidents were proposed. Using this approach and applying risk management process in order to control the key hazards which can minimize the occupational accident rate.

2 MATERIALS AND METHODS

2.1 *Study sites*

This study was conducted by using historical incidents data in a six year-period from 2011 to 2016 at Holcim Cement Vietnam (Ltd.). Holcim Cement Vietnam (Ltd.) was a member of Holcim Group and consisted of one cement plant, three cement grinding stations operating in the south of Vietnam. The location of study sites was shown in Figure 1.

Cement manufacturing process comprises of crushing, grinding, raw meal preparation, kiln burning and cement production basically (Cankaya, 2015). Figure 2 shows the process flow of a typical cement plant:

2.2 *Data processing and analysis*

Basing on analyzing and practical observing cement manufacturing process, the high risk activities in cement industry were proposed. On the other hand, the recorded incidents data included occupational accidents, near-misses incidents and hazards reported in a six-year period from 2011 to 2016 at one cement plant and three cement grinding plants belong to Holcim Cement Vietnam Company were collected, and analyzed in order to find out the causes of these incidents. The Pareto

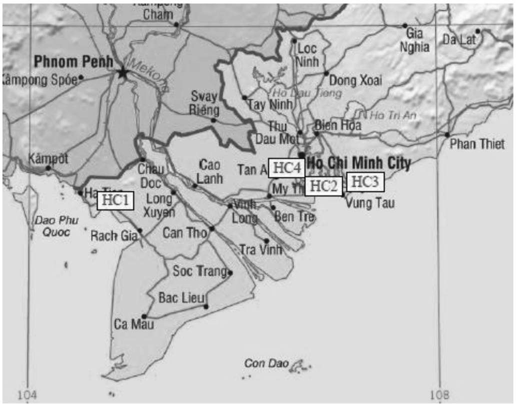

Figure 1. Study sites belong to Holcim Cement Vietnam (Ltd.).

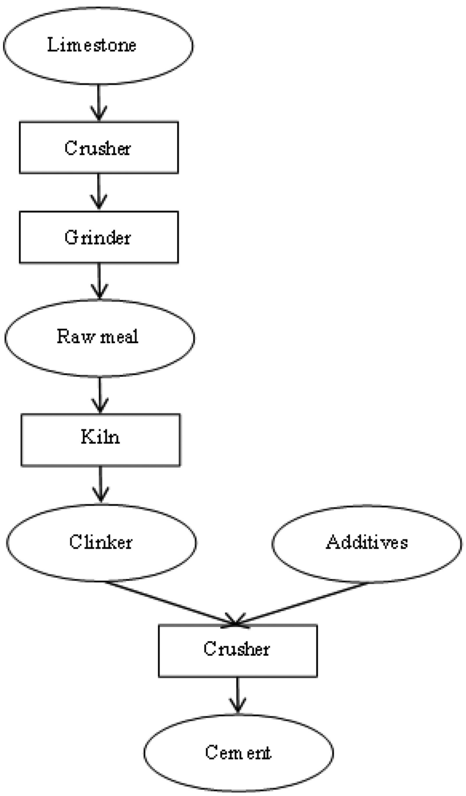

Figure 2. Simplified process flow of a typical cement manufacturing (Cankaya, 2015).

charts were used to show the hazard categories accounted for 80 percent in the total hazard categories which were occurred and mainly caused occupational accidents in cement industry. Finally, the control approaches of the critical hazards in cement industry were recommended by applying risk management process.

3 RESULT AND DISCUSSION

3.1 *High risk activities in cement industry*

Each process in cement manufacturing always contained the risk for worker as its nature. However, there were some main activities which produced high risk and caused major accidents included quarrying, raw material preparation, kiln operation, doing specific activities such as silo cleaning, working at height activities, doing maintenance of energized machinery and transportation activities. The processes and their relevant risk to worker were explained in Table 1.

3.2 *Safety performance from 2011 to 2016*

The accident rates represent the number of injuries per 100 full-time workers or per 200,000 hours worked (WCBSD, 2013) at study sites were shown in Figure 3.

The total injuries frequency rates for employees and subcontractors in a six-year period from 2011 to 2016 were fluctuated from 0.03 to 0.49 and the Lost Time Injuries Frequency Rates (LTIFR) for all employees and subcontractors were the lowest rates in 2012, 2013 with zero and the highest rates in 2011 with 0.27, the rates were 0.03 for 2014, 2016 and in 2015 was 0.17. These LTIFRs were lower than incidence rates of nonfatal occupational injuries and illnesses of Cement and concrete product manufacturing in U.S.A. in 2015 which was 1.9. However, the incidence rates of cement and concrete product manufacturing in United States in 2015 was 1.9 included illnesses rates which were not calculated for above LTIFRs statistics.

3.3 *The hazard categories based on recordable incidents and hazards from 2011 to 2016 at the study sites*

After analyzing incidents data, the hazard categories in a six-year period from 2011 to 2016 at study sites were shown in Figure 4 and Figure 5.

The hazards in cement industry were varied and mainly related to seven key elements included working at height, electricity, vehicles operation, moving machinery, improper ladders/stairs/walkways, housekeeping/environment and signage. However, the percentage of these hazard categories can be changed amongst study sites basing on some key factors such as safety design, safety culture, worker's competency and safety management

Table 1. The high risk activities in cement manufacturing and their major relevant occupational risk to worker.

High risk activities	Major occupational risks
Quarrying Limestone at quarry was prepared by using explosive and then all types of raw material included limestone, clay were transported to the plant by heavy trucks.	Risk of injury during using explosive; Risk of fall from height due to standing at the edge of the rock without adequate protection measures; Risk of truck turnover and caused occupational accident due to driving in the sloped road;
Raw material preparation All types of raw material include limestone and clay were transported by belt conveyor system to raw mill for grinding and then were stored in silos.	Risk of entanglement by working near, on or under moving parts of belt conveyor system without guarding and proper protection measures; Risk of electric shock when working with or repairing live electrical appliances;
Kiln process Raw material in silo was transferred and fed into rotary kiln which heated by a 2000°C flame inside of it (Cankaya, 2015). The most commonly fuels used for kiln were coal, rice husk and occasionally oil. After cooling process, clinker was transported by belt conveyor system and stored in silo.	Risk of burn when expose to high temperature; Risk of entanglement by working near, on or under moving parts of belt conveyor system without guarding and proper protection measures;
Doing specific activities Worker in cement industry usually conduct specific activities which potentially caused occupational accidents such as silo cleaning, working at height activities and doing maintenance of energized machinery.	Risk of burying by cement when doing cleaning inside cement silo without safe working method; Risk of fall from height and falling objects when doing activities at height without fall protection countermeasures and adequately measures; Risk of electric shock or entanglement when doing maintenance activities without lock out, tag out;
Transportation Transportation of raw material, cement by using heavy vehicles such as dump trucks, wheel loaders, and bulk tankers was one of the activities which potentially produced high risk to driver, worker and inhabitants.	Risk of collision between these types of vehicles and pedestrians in site and off site; Risk of turnover of trucks when operating in danger zones; Risk of fall from top of bulk tanker because of inadequate fall protection measures;

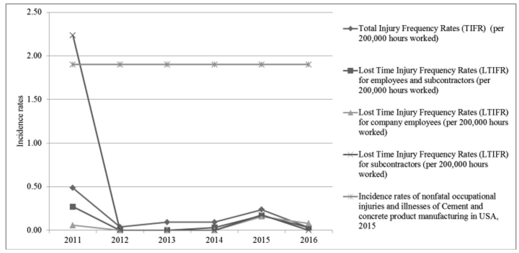

Figure 3. Safety performance from 2011 to 2016.

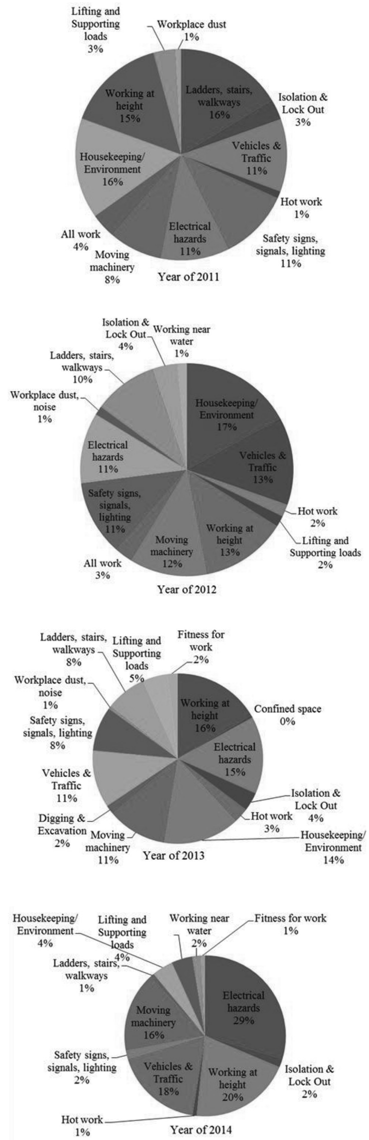

Figure 4. *Continued.*

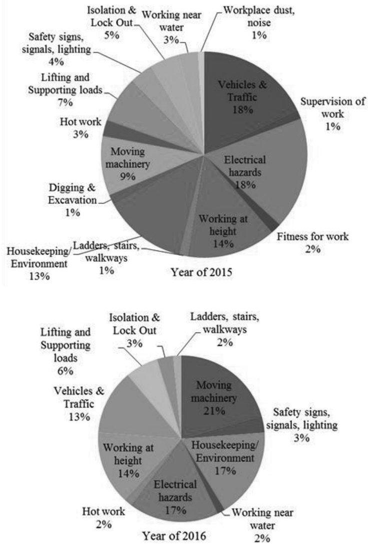

Figure 4. The percentage of hazard categories from 2011 to 2016.

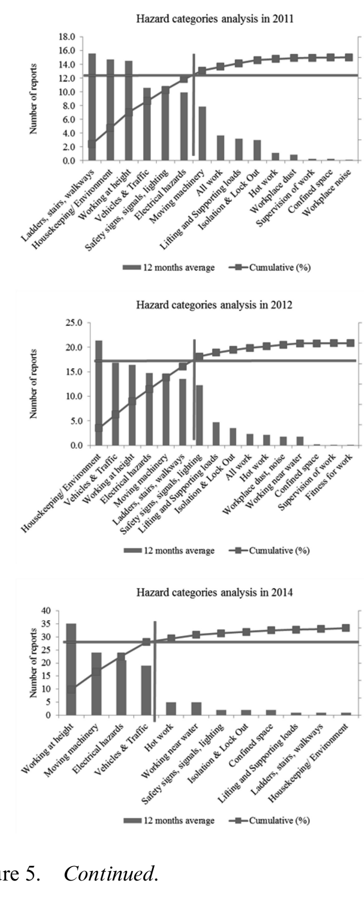

Figure 5. *Continued*.

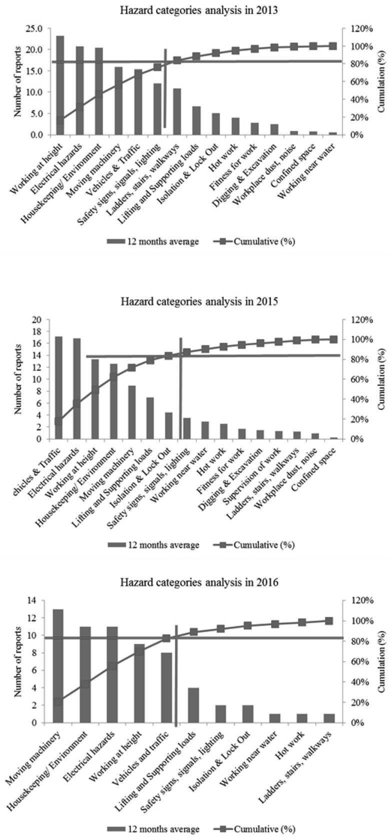

Figure 5. The Pareto charts of hazard categories from 2011 to 2016.

Table 2. The top five hazard categories in cement industry.

Priority	Hazard categories	Weight (%)
1	Working at height hazards	20
2	Electrical hazards	18
3	Vehicle and traffic hazards	16
4	Moving machinery hazards	16
5	Workplace environmental hazards	15

system. The following Pareto charts were pointed out the key hazard categories which accounted for 80 percent in the total hazards of analyzed incidents.

The Pareto charts shown the weight of key hazard categories in cement industry which analyzed from incidents history from 2011 to 2016 in study sites. The key hazard categories at study sites which accounted for 80 percentages of incident causes during study period included:

3.4 *Risk control approach*

In order to control the risk and prevent occupational accidents in cement industry, the five basic risk assessment steps should be applied included (1) look for the hazards; (2) decide who might be harmed and how; (3) evaluate the risks and decide whether existing precautions are adequate or more should be done; (4) record the significant findings and (5) review the assessment and revise it if necessary (Hughes & Ferrett, 2011). When determining risk controls, consideration shall be given to reducing the risks according to the following hierarchy: elimination; substitution; engineering controls; administrative controls; personal protective equipment (Thai, 2016).

4 CONCLUSION

The Pareto principle was used to identify the main hazard categories caused occupational accidents (Gorny, 2015) in cement industry by analyzing historical incidents data in a cement company. The top five hazard categories which were identified and mainly occurred in cement plant included working at height hazards with 20%, electrical hazards accounted for 18%, vehicle & traffic and moving machinery hazards accounted for each with 16% and finally with 15% was workplace environmental hazards. By analyzing the main causes which caused incidents and then focusing on controlling these hazards properly so that the major occupational accidents in cement industry can be prevented. Additional, the occupational accidents can be occurred due to unsafe acts or/and unsafe conditions (Strank, 2008). So to prevent occupational accidents from happening, the behavior of employees, contractor and other third-parties must be controlled properly beside the unsafe conditions improvement and control.

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Patterns of safety. Overarching results and conclusions from a comparative study of safety in the Swedish and Danish construction industry—SveDan

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ABSTRACT: The reported occupational accident rate in 1998–2010 was twice as high in Denmark as in Sweden. In the construction industry, the difference in the fatal accident rate between these countries was 40%. The aim of the SveDan research program was to identify phenomena at different societal levels that may explain the latter difference. The program was performed by a Danish and Swedish research team and comprised multi-method comparative studies with different data sources. The results verify the previously found difference in accident rates between Denmark and Sweden, also in construction industry, and indicate that this difference mirrors actual differences in occupational safety. The results provide a pattern that may help to explain the difference and that indicates a difference in how power and influence are dealt with and distributed within the construction industry systems. This influences the relations between different functions, groups and individuals, which in turn, influence workplace safety.

1 BACKGROUND

During 1998–2010, the incidence of reported occupational accidents was twice as high in Denmark (DK) as in Sweden (SE). In 2003–2008 the difference between the two countries in the fatal accident rate was 33% (Tomasson et al., 2011). In the construction industry, many exposure conditions are similar in DK and SE, yet the difference in the rate of fatal accidents in this branch was 40% (Tomasson et al., 2011). Similar differences were found by Spangenberg and colleagues (2003).

1.1 *Aim of the SveDan program*

The aim of the SveDan research program was to identify phenomena at the macro-, meso- and micro-level (Landeweerd 1990, Spangenberg 2003) that may explain the large SE/DK difference in accident frequency in the construction industry. Such knowledge can illuminate factors that are essential for safety in construction, and possibly also in other occupational branches. This may be used to improve the efficacy of accident prevention in both SE and DK, and to inspire other countries in their preventive strategies.

2 METHODS

The SveDan research program was performed in 2013–2016 by a team of researchers from SE and DK. It comprised a number of multi- and mixed-method comparative sub-studies in the Swedish and Danish construction industry. In order to study this complex safety phenomenon we divided the key factors into three levels. Macro-level phenomena included legislation and the implementation of law, insurance systems, branch structure, gender, age, and educational level within the construction industry. Such phenomena set the outer conditions and limits for safety. Meso-level phenomena included differences in the vocational education and training systems that are important for moulding social norms, and individual attitudes, cognitions and behaviours. Micro-level studies focused on students' attitudes and cognitions in their socialization to become construction workers. We also studied safety leadership, workplace safety climate and construction workers' attitudes and behaviours. All studies were performed in both SE and DK, applying the same methodology, and by participation of researchers from both countries, in order to secure comparability, and minimize bias.

3 RESULTS

3.1 *Comparison of accident frequencies*

Fatal accidents in both SE and DK labour markets showed steady and significant downward trends during 1993–2012 (IRR: 0.95; 95% CI: 0.95–0.96), but the relative risk (IRR) in DK was 1.12 in comparison to SE (95% CI: 1.03–1.22), when controlled for differences in gender, age and occupational structure. In the construction industry, specifically, the Danish IRR for fatal accidents was 1.45 (95% CI: 1.19–1.76) relative to Sweden.

Analyses of all reported occupational accidents showed a difference in accident frequency due to age, with younger workers having higher accident frequency. However, this difference was reduced when controlling for educational level and type of occupation; younger workers more often lacked vocational education and held manual jobs.

Large companies (all branches) reported more accidents than smaller ones, which is likely due to better reporting procedures. This difference did not, however, seem to explain the difference between the countries. A larger proportion of the employees in the Swedish construction industry is employed in companies with less than 10 employees (SE 33%; DK 24%). However, SE also had a larger proportion employed in construction companies with more than 250 employees (SE 30%; DK 8%).

The IRR was 1.28 for employees without vocational education. It was more common among the Danish workers to lack such education, and this difference increased during the study period. In SE, the proportion without vocational education decreased steadily, while it remained rather constant in DK (SE: 33% to 20%; DK: 32% to 28%). SE also had an increasing proportion of employees in the construction industry with a higher-level education, while this remained constant in DK. The proportion of female employees in construction, below 10%, was similar and constant over the period in both countries.

The SE/DK difference in accident frequency remained when controlling for age, gender, education, occupational branch, occupation and company size. We were not able to control for differences in the propensity to report accidents. However, we assume that the differences in incidence of accidents are not attributable to reporting differences alone since the country difference remains when comparing fatal accidents, which are least prone to reporting bias.

3.2 *Work environment law and law implementation in Denmark vs. Sweden*

The frameworks for occupational health and safety (OSH) laws are similar in SE and DK, as both countries are members of the UN International Labour Organization (ILO), and EU and have ratified and implemented the same directives. Previous investigations have revealed some minor differences between the two countries (Arbetsmiljöverket and Arbejdstilsynet, 2001; Rögnvaldsson et al., 2011). For one, in Sweden, the employees' OSH representatives are elected by the trade unions, whereas in Denmark they are elected directly by the employees. Also, in Denmark the builder (in the construction industry) can delegate the OSH responsibility to a main contractor, while this is not possible in Sweden. We identified some further differences in the implementation of the law that may be of relevance. Firstly, unlike the Danish OSH law, the Swedish law covers also one-person companies and small family businesses, as well as students. The latter implies that students elect their OSH representatives at the schools, and thus the students in SE early in life are encouraged to engage in OSH issues.

Secondly, there are some differences in how the OSH work is structured in the companies. The law in both countries prescribes that employers and employees should cooperate in the OSH work. The work is organized through an OSH committee with participation of both parties, but in Sweden, the participation of union representatives is more clearly mandatory. In addition, in Sweden, companies with at least five employees should have such a committee and in even smaller companies, a regional OSH representative provides support. This is a person educated in OSH regulations, with full time employment in the trade union for this type of work and often with extended knowledge and experience of these issues. In Denmark, the requirement for a joint OSH organization applies to companies with ten or more employees, and there is no equivalent to the regional OSH representatives.

Thirdly, the national labour inspectorates differ somewhat, both in relative size and the way they perform the inspections. The DK labour inspectorate (Arbejdstilsynet) for a number of years has performed more workplace inspections per year than the Swedish counterpart (Arbetsmiljöverket), in spite of SE having almost twice the population. In 2009, DK had 420 inspectors compared to 286 in SE (Rögnvaldsson et al., 2011). In 2006, the Swedish government substantially reduced the budget for the inspectorate, which resulted in a reduction in the number of inspectors from 389 to 235 in 2014 (Axelsson and Spira, 2014). Similarly in DK reductions began in 2012, and in 2016 the number was 304 (Poulsen, 2017). Although the manner in which inspections are performed has not been constant over the years in either of the countries, there is presently a general difference. In both countries, the inspectors are authorized to shut down all work at a workplace if conditions are considered to pose immediate risks for life or health. Other than that, however, the Swedish inspectors, contrary to the Danish, up until 1st July 2014 were restricted to issuing orders of improvement. They were not authorized to issue fines or other sanctions directly at the workplace (Lyttkens, 1994). Only in case of non-compliance to previous orders of improvement, fines were issued. Such a soft legislation may diminish the incentive for the companies to follow the law. It may also, however, encourage an inspection style with a strain of negotiation, aimed at convincing the companies about the benefits of a safe and healthy working environment (Lyttkens, 1994). In order to look further into the inspection practices, a mixed-method approach was employed, combining observations of inspections, interviews with inspectors and questionnaire responses from inspected workplaces. The results showed that the primary role of both DK and SE inspectors was as controllers. A minor role was as experts, providing knowledge and solutions. A third role of being a sounding board was identified only in a few instances, all in SE. In such cases, the inspector sought to stimulate a problem solving dialogue with the inspected company. While the controlling and expert roles place the formal power in the relation with the inspector, informal power is distributed more equally when the inspector acts as a sounding board. Coercive tactics were more common in DK, while autonomy-supportive tactics were more common in SE, where such a strategy also took up a larger portion of the time of the inspections. Negative behaviour from the inspected company was more widespread in DK while positive behaviour was more common in SE. Questionnaire data showed that the inspected SE companies had significantly more positive perceptions of the inspectors and the benefits of the inspections (Nielsen, 2016).

We conclude that differences in the national work environment law does not explain the SE/DK difference in accident frequency. However, some differences in the implementation of the law may be important since they create formal and informal structures that affect worker and union influence in the companies, and may affect the companies' ability and will to engage in OSH development.

3.3 *Comparison of insurance systems for occupational injuries*

In DK, private employers are obligated to insure their employees against accidents by taking out an insurance in one of 13 private insurance companies (COWI, 2013). Occupational injury insurance premiums represent 30–60% of the total insurance premiums in these companies. Public employers are insured through the taxation system. The company insurance premiums are based on a set rate multiplied by the number of employees. The set rate is subject to competition between the insurance companies, and may be adjusted for a single company, and in particular companies with more than 50 employees. The negotiating of a lower insurance premium may include consideration of the company's safety level and experience rating. The DK system is based on the assumption that a differentiated insurance premium will be an incentive for prevention, and that competition between the insurance companies will result in lower premiums. However, the effects of this have not been well evaluated.

The SE employers pay social fees to the government, which also covers insurance premiums to the government owned Försäkringskassan (FK). The insurance premium is the same for all types of work. The insurance guarantees compensation for lost income up to a certain level. FK also coordinates rehabilitation. No compensation is paid out for the first day of sick-leave. Thereafter, the employer covers the costs for the following 14 days. Costs beyond the two weeks are covered by FK. AFA Insurance, an institution owned by the labour market parties, complements FK. These insurances are regulated in agreements between the labour market parties and cover 4 million employees and 90–95% of all companies. The AFA insurance covers lost income up to 100% and compensation for other economic loss, and suffering. There is thus a strong incentive for employees in SE to have their occupational injury reported, but none for the employers. In addition, AFA cooperates with knowledge transfer institutions, also jointly owned by the parties of the labour market.

Our general conclusion is that in both SE and DK the insurance systems offer little incentive for the companies to reduce occupational risk exposure proactively. The insurance companies do not themselves work proactively towards the companies in any systematic manner, and they apply work life research to a low degree, e.g. as a basis for setting requirements for the companies' own proactive work. We do conclude, however, that the Swedish system has a somewhat larger potential for prevention than the Danish. The differentiated insurance premiums in the DK system may encourage underreporting (experience rating-differentiation). Not reporting an accident is considered as insurance fraud, but the risk of detection is low. Employees in DK have a certain (weak) incentive to report accidents, in case they turn out to result in severe and long-term health consequences. The SE set rate system offers no incentive for companies to proactively reduce hazards and thereby costs. High accident rates will influence the sector rate levels in the long term, but have no immediate effect. The SE system does not encourage under-reporting, and there is strong incentive for the employees to make sure work accidents are reported.

3.4 *The vocational education and training and consequences for students safety development*

In this study (Grytnes et al., 2017) we compared the SE/DK vocational education and training (VET) systems, focusing on differences that may be important for students' safety learning and practice. In both countries, students participate in full-time education, and the curriculum includes school-based as well as company-based training, but there are differences in how the curricula are organized.

In DK short periods at school alternate with longer periods in the training company. This reduces the possibility for the school and its teachers to influence the students' safety practice. It also contributes to the Danish students rather quickly attaining an identity as construction workers rather than students. This is contrary to Swedish conditions where the students alternate between a few days at school and a few in the training company, and maintain an identity as students throughout their education.

The Danish students are themselves responsible for recruiting a company that will employ them as apprentices. The school is thus unable to influence this choice, and the approval of firms eligible for apprentices is not based on a detailed evaluation of their OSH performance. The school is also unable to pose safety demands to the worksite management. When students experiencing safety problems at their worksite seek support from the school, the teachers can only refer them to the trade union or advise them to point out the problem to their company supervisor. Since it is generally difficult to find an apprenticeship, students are not inclined to criticize the safety conditions to their worksite management. This disinclination is further enhanced by the fact that the students are salaried directly from the companies during the entire training period. Voicing behaviour (e.g. suggestions for improvements or criticism) is thus early discouraged and the students are likely to be socialized into a culture of not openly questioning authority.

In SE, the schools are responsible for finding companies for student training. Safety conditions are clearly stated criteria in this selection. The teachers also generally make repeated visits to the worksites to ensure acceptable working conditions for their students. If a student puts forth safety complaints to their teacher, the teacher will visit the worksite and pose demands on improved safety. If these demands are not met, the school can terminate the training company agreement and find a replacement company. Swedish teachers described their role in relation to the worksites as the 'students advocate'. These role structures empower the students and encourage voicing behaviour.

The Danish curriculum, contrary to that in SE, comprises specific courses regarding OSH. This probably contributes to better knowledge and understanding about these issues, and the DK students referred to their teachers as their main source of safety knowledge. However, if the students feel unable to act in accordance with this knowledge at the worksites, it may lead to perceived role conflict (Kristensen et al., 2005). The DK students to a greater degree than their SE counterparts reported role conflict between the school's expectations on their safety behaviour, and the expectations from their worksite.

We conclude that the structure and distribution of influence and responsibility in the Swedish system for vocational education and training empowers the students and encourages a voicing behaviour concerning safety. The Danish vocational training structure promotes socialization into existing social norms, encourages adaptive behaviour and discourages voicing. It also disempowers the schools to counteract such adaptive processes. We believe, that these differences in the structure of the Swedish and Danish vocational education and training curricula and roles may explain some of the difference in accident frequency between the two countries.

3.5 *Attitudes and conceptions among students in vocational training for construction work*

A two (DK) and three (SE) wave questionnaire study was carried out among students in construction industry vocational education and training (Grill et al., 2017a). The study was directed toward all construction work students at three Danish and four Swedish schools. The results showed consistent and clear national differences. The SE students expected more relational and involving leadership from their future managers than did the DK students. The Swedes expected to participate more in planning and decisions in their future work, and valued safety organizational citizenship behaviour higher (OCB; Organ, 1997; Podsakoff et al., 1997). When controlling for age, SE students were more motivated to work safely, but SE and DK students perceived the same extent of safety self-efficacy (Chen et al., 2001). The Swedish students valued a proactive approach to safety (Probst et al., 2013) higher than the Danish. The Danes had a more external safety locus of control (Janicak, 1996) and, in line with this, stated less personal safety compliance behaviour (Mearns et al., 2003) as well as participative safety behaviour (Fugas et al., 2012) than the Swedes. Danes and Swedes rated their teacher related safety climate (Kines et al., 2011) equally high, but the workplace safety climate was rated higher among the Swedish students. The results also showed that Danish students valued assertiveness higher and were less conflict avoidant.

Counter to our expectations, the Swedes considered it more important to obey their leaders. They were also more extrinsically work motivated, while the Danes were more intrinsically so.

Most of the phenomena did not change over the education period. Most of the differences between the countries were present already at the start of the vocational education. This means that the students already had acquired these attitudes prior to the vocational education, and not because of it, and we conclude that they mirror differences in the national culture. Some phenomena did change with time, however. The most prominent change was that the attitude that one should obey ones' leaders decreased in SE but remained stable in DK. School/workplace role conflict increased in both countries, as did the opinion that leaders should involve their employees in decision-making. External locus of control showed a slight decrease in SE but not in DK.

3.6 *Structured safety observations in the school workshops*

In this study (Kines et al., 2015) 3654structured safety observations were done in the carpentry workshops at three Swedish and three Danish schools (SE 45% of observations; DK 55%). We observed working conditions (access routes, housekeeping, protective rails), use of personal protective equipment (PPE), and teachers' and students' behaviour in the use of hazardous equipment. As shown in Table 1, the results showed no significant differences in the generic safety index (index = 100 × correct observations/all obs.) between the two countries (SE 88.0% safe observations, DK 88.3%; Factor: 88.3/88.0 = 1.004 [CI: 0.980–1.028], Fisher's exact test p = 0.758). However, there were significant differences between the three schools within each country. (SE: Factor 1.049 [CI: 1.005–1.096] p = 0.033; 1.063 [1.014–1.114] p = 0.015); DK: Factor 1.075 [CI: 1.036–1.114] p = 0.000; 1.066 [1.027–1.107] p = 0.002).

Table 1. Safety indices (SI), measured three times at each of three SE and three DK school carpentry workshops.

Schools	Obs. 1 SI%	Obs. 2 SI%	Obs. 3 SI%	Total SI%
Swedish:				
SE-1	81.4	89.7	93.7	89.2
SE-2	80.8	84.7	89.7	85.0
SE-3	87.1	95.8	89.0	90.3
SE, all	82.7	89.5	91.1	88.0
Danish:				
DK-1	90.3	93.9	94.8	93.0
DK-2	82.8	84.1	91.4	86.6
DK-3	83.3	89.8	89.7	87.3
DK, all	84.8	88.2	91.5	88.3

We conclude, that the safety level, as observed in this study, differs between schools but this difference does not explain the SE/DK difference in accident frequency in the construction industry.

3.7 *Safety management and employee safety responsibility in Swedish and Danish construction industry*

In this study, we performed semi-structured interviews with five construction managers and four construction workers in DK and SE (Grill et al., 2015). All but one of the participants had previous experience of working in both countries. One had worked in Sweden and Norway, but was acquainted also with work in Denmark. The transcripts were analysed using semantic thematic analysis.

Seven themes represented the professionals' perceptions of what may contribute to explain the SE/DK differences in construction accident rates. The themes indicated safety culture differences between the SE and DK construction industries. Interconnections between the thematic areas revealed patterns of interaction between managers and employees, interpreted as typified process models of participatory and directive safety cultures, and described different mechanisms for how the leadership influenced workers' safety behaviour. Both the participative and the directive process types were described to occur in both countries, but the participants jointly described the participative approach to be more common in SE, and the directive approach to be more common in DK. A participatory management style, promoting long-term planning, encouraging cooperation, caution and compliance to rules, but also workers giving voice to concerns and challenging authorities when they identified problems or had suggestions for better solutions, were phenomena that were described as connected to successful safety management. Such phenomena defined the participative approach and were supported by secure and long-term employment.

3.8 *Safety leadership*

We performed two sub-studies of safety leadership. One sub-study was based on a representative sample of 22 Swedish and 15 Danish construction worksites, each employing at least 20 workers. We studied construction site managers' behaviour, in terms of transformational, active transactional and passive/avoidant leadership, and how these behaviours related to workers' safety climate perceptions (Grill et al., in review). We combined structured observations of construction site managers' day-to-day interactions with their employees and subcontractors, questionnaire responses from construction workers, and contextual background information regarding the site managers and their sites.

The DK and SE site managers had approximately the same amount of experience in this role, but the Danes were about five years younger. The SE managers had longer experience as construction workers prior to becoming managers. The SE managers spent almost all their working hours at the construction site, whereas their DK counterparts were on site about half of their work time, and many were managers at more than one site. It was twice as common for the SE managers to have a subordinate manager on the site, although the average number of workers on site was the same in the two countries. Almost all of the SE managers had a formal role as worksite safety coordinator, while this was the case only for a third of their DK colleagues.

Transactional leadership was the most common type of leader behaviour in both countries, but was more common in DK. Transformational leadership was instead more common in SE. Passive/avoidant leadership was least common and equally common in both countries. At sites where the managers more commonly practiced transformational leadership, the construction workers rated the safety climate as higher. A high proportion of observed passive/avoidant leadership predicted low safety climate. The proportions of transformational and passive/avoidant leadership among the site managers explained a large portion of the variation in safety climate between the sites. We also found that site managers who had a large number of subcontractors on the site practiced less transformational and more transactional leadership. Site managers who themselves had longer previous experience of working as construction workers also practiced a larger portion of transformational leadership.

A second leadership sub-study was based on questionnaire responses from workers at a representative sample of Swedish and Danish construction sites (Grill et al., 2017b). Workers from 48 Swedish and 37 Danish sites responded (total site response rate 73%). We investigated the relation between different leadership styles and safety climate, safety behaviour, and self-reported accidents.

We found that transformational, contingent reward and participative leadership styles were positively related to safety in both countries. However, participative leadership had a stronger positive effect in SE than in DK. Participative leadership was also more common in SE. An interesting finding was that a positive effect of rule-oriented leadership on workers' safety behaviour was moderated by the level of participative leadership. This means that rule oriented leadership was positively related to individual safety behaviour only if participative leadership was also practiced. This suggests that if rules and plans are established in a participative manner, involving the construction workers in decision-making processes, then these workers will be more motivated to comply with safety regulations and participate in proactive safety activities.

3.9 *Construction workers attitudes and perceptions*

All respondents in the questionnaire study to construction workers were male, and all spoke either Swedish or Danish. Mean age in both countries was 39 years. The portion with a vocational education was higher in SE (SE: 87%; DK: 71%), which is in concordance with the results of the register study (Section 3.1, above). It was more common in SE to have long-term employment (SE: 38%; DK: 8%), whereas employment on an hourly basis was more common in DK (DK: 55%; SE: 31%). Approximately one third of the workers in both countries were also paid piece rate.

Almost 30% of the workers in both countries were employed in companies with less than 20 employees, but more Danes were employed in companies with 20–100 employees (DK: 55%; SE: 37%), and 1/3 of the Swedes were employed in companies with >100 employees, while this was the case for only 19% of the Danes.

Table 2 presents individual attitudes and perceptions of conditions at the present work site, showing significant differences between the Swedish and Danish workers. Table 3 provides results of the self-reported observations of alcohol use at the construction workers' own worksites, showing a significantly higher propensity of drinking and intoxication at the DK than at the SE construction sites. Workers' accident experience in the previous three months is provided in Table 4, showing a higher self-reported accident frequency in DK, but no difference between the countries in workers' propensity to report accidents to their superiors. Table 5 shows the predictor variables that were significantly related to workers' self-reported safety behaviour among the Swedish and Danish respondents, respectively.

3.10 *Structured safety observations at Danish and Swedish construction worksites*

Here, as in the observations of safety in the school workshops (section 3.6, above) we made structured observations of three phenomena: working conditions (access routes, housekeeping, protective rails); use of PPE, and workers' behaviour in the use of hazardous equipment. We made, in all, 6657 observations at 23 different worksites (DK: 12 sites; SE: 11 sites).

Table 2. Attitudes and perceptions with significant difference between SE and DK construction workers. (Item scale range within brackets, left).

Workers' attitudes	SE M (SD)	DK M (SD)	Effect size
Self-assertiveness (item scale range: 1–7)	2.74 (1.40)	4.07 (1.59)	0.88
External safety locus of control (1–6)	2.97 (0.95)	3.58 (0.79)	0.70
Extrinsic work motivation (1–6)	4.60 (0.65)	4.29 (0.69)	0.47
OCB, (1–6)	4.88 (0.71)	4.63 (0.67)	0.37
Future orientation, safety (1–6)	5.13 (0.78)	4.87 (0.83)	0.33
Cooperation (1–6)	5.06 (0.67)	4.85 (0.72)	0.30
Power distance (1 item; 1–7)	2.87 (1.51)	2.45 (1.43)	0.30
Intrinsic work motivation, (1–6)	4.80 (0.68)	4.64 (0.77)	0.22
Participative safety behaviour (1–7)	5.07 (1.14)	4.83 (1.13)	0.21
Workers' perceptions of conditions at the present work site:			
Present constr. project well planned (1–6)	4.17 (1.05)	3.48 (1.15)	0.62
Safety climate (1–6)	4.47 (0.77)	4.10 (0.70)	0.51
Participative leadership (1–7)	4.87 (1.08)	4.42 (1.17)	0.39
Rule oriented leadership (1–7)	4.24 (0.91)	3.93 (0.86)	0.36
Cautious leadership (1–7)	4.06 (0.91)	3.84 (0.86)	0.25
Active management-by-exception (1–7)	4.24 (1.16)	4.48 (1.06)	0.22

Table 3. Observations of alcohol use during the working day, at own worksite, in the last 12 months.

	SE	DK	Diff. (p)
Co-worker drinking alcohol during the working day	5%	31%	0.000**
Co-worker intoxicated at work	5%	15%	0.000**
Co-worker hung-over at work	43%	42%	0.873

Table 4. Workers' accident experience last 3 months.

	SE	DK	Diff. (p)
Accident causing cessation of work ≥ 1 hr	10%	16%	0.022*
Proportion of the above accidents that were reported to a superior	79%	69%	0.25

Table 5. Bivariate correlations between predictors and self-rated safety behaviour (* = p < 0,05; ** = p < 0,01).

Relation to safety behaviour		
Workers' attitudes	SE	DK
External safety LOC	–0.16**	–0.14**
OCB	0.19**	0.13**
Future orientation, safety	0.31**	0.34**
Cooperation	0.24**	0.15**
Intrinsic work motivation	0.20**	0.09
Perceptions at present site		
Planning	0.16**	0.17**
Participative leadership	0.27**	0.19**
Rule oriented leadership	0.23**	0.12*
Cautious leadership	0.13*	0.10*
Active management-by-exception	0.14**	0.14**
Observations previous 3 months		
Colleague drinking alcohol during workday	–0.12*	–0.07
Colleague being hung-over at work	–0.11*	–0.17**

The safety index was calculated (index = 100 × correct observations/all obs.). The overall results showed a non-significant between-country difference in the safety index of 1.2% (SE: 86.5%; DK: 85.4%. Factor: 86.5/85.4 = 1.012 [CI: 0.991–1.034], Fisher's exact test $p = 0.273$), but large variation between different worksites within each country (safety index range: SE 72–97%; DK 78–95%).

We conclude, that the observable safety level at construction worksites, as observed in this study, differs between sites but it does not explain the SE/DK difference in accident frequency in the construction industry.

4 CONCLUSIONS

We did not identify any singular factor that could explain the observed differences in the incidence of accidents in the Swedish and Danish construction industries. However, when the results of the different sub-studies of the SveDan research program are viewed concomitantly, a pattern emerges. This pattern is largely grounded in how power and influence are dealt with and distributed in the construction industry system, and how this, in turn, influences relations between different functions, hierarchical levels and individuals, in a manner that affects safety at work. We conclude, that formal and informal structures in the Swedish construction industry system, and perhaps also beyond this system, have supported vertical proactive cooperation across hierarchical levels. Such formal and informal structures have encouraged subordinate functions (e.g. companies vs. government authorities) and empowered individuals (e.g. workers or students vs managers) to take active part in the planning of work by participation in problem solving, and voice behaviour. This has contributed to self-reinforcing mechanisms consolidating cooperative attitudes and work relations in the Swedish construction industry. In the Danish construction industry, other structures have created self-reinforcing mechanisms that have rather reinforced authoritative, and thus more confrontational, work relations. However, it should be emphasized that cooperative attitudes and work relations need to be continuously supported, reinforced and further developed in both Sweden and Denmark.

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Prevention cultures and OSH interventions—European experiences with implementing the zero accident vision (and its potentials for health and wellbeing at work)

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ABSTRACT: A growing share of European companies is strongly orientated on "Vision Zero". So we want to look more deeply on this strategy by moving to a European level and pre-sent the strategies and challenges of 27 Zero Accident Vision (ZAV) committed companies from seven EU countries. They focus thereby was on (safety) commitment, communication, culture and learning, but also on the challenges of broadening their approaches to fully address health issues. How they have implemented their strategies can give hints for how to develop strategies for supporting and implementing a broader "Vision Zero".

1 BACKGROUND

1.1 *The Zero Accident Vision*

There is an increasing political and research interest in the implementation of the Zero Accident Vision (ZAV) and the broader Vision Zero (VZ).

According to Zwetsloot et al. (2017a), this broader Vision Zero is "the ambition and commitment to create and ensure safe and healthy work and to prevent all accidents, harm and work-related diseases in order to achieve excellence in health, safety and well-being". (Zwetsloot et al 2017a). So far, the research literature main addresses the narrower ZAV.

Some authors emphasize the potential benefits of ZAV (e.g. Salminen, 2015, Zwetsloot et al. 2013, see also the keynote speech of Konkolewsky at this conference—Konkolewsky 2017), whereas others are critical about the concept (e.g. Dekker 2014). However, only a few empirical studies that shed light on ZAV implementation are available (e.g. Young 2014; Koivupalo et al., 2015; Twaalfhoven and Kortleven, 2016). Here we elaborate on the findings presented in Zwetsloot et al. (2017b).

The study concerned a multinational study involving 27 (mostly large) companies that have adopted ZAV and are in the process of implementing ZAV. The research focused ZAV commitment, safety communication, safety culture and safety learning. It was carried out in Belgium, Denmark, Finland, Germany, Netherlands, Poland and United Kingdom. The sectors involved were manufacturing, construction and 'others'.

2 MAIN STARTING POINTS FOR THE RESEARCH

2.1 *Four focal points: Commitment, communication, culture and learning*

Zwetsloot et al. (2013) suggested that the implementation of ZAV requires a 'commitment strategy': the commitment from top management within and outside a company, as well as from the individual workers may boost safety culture and performance. Commitment is thereby regarded as active and visible support, particularly from senior managers.

Safety communication was regarded important to share the Vision of ZAV with all of its personnel; it is also otherwise important for good safety management.

Safety culture was regarded as important for 'anchoring' the ZAV commitment of individuals in the collective of the organization.

A further assumption was that ZAV, as a paradoxical goal (it cannot expected be achieved by using only the traditional safety tools) needs learning and innovation.

2.2 *Materials and methods*

The research was designed as a 'mixed method' research, combining a quantitative survey among managers and workers (8,819 respondents), with a limited number of half-open interviews per company and national workshops. The research was carried out by researchers of the respective countries, coordinated by TNO (Netherlands) and mainly funded by the German Social Accident Insurance (DGUV, Germany).

The survey, called the PEROSH ZAV Survey, is described in Zwetsloot et al 2015 (p. 74–78). It consisted initially of 72 items (one was later removed) and 11 topics. In the three German companies 4 additional items forming one topic (the interaction between prevention in the areas of safety versus health) was also measured (2,068 respondents). Answers were given on a scale from 1 (poor) to 4 (good).

The reliability of all topics was good.

Around 30% of the respondents were managers, around 66% of the responses were from workers. One company only wanted to participate when no managers and worker responses were distinguished (around 4% of the responses). The seven construction companies were relatively large: 51% of the respondents were from that sector.

Detailed results are presented in Zwetsloot et al 2017b and Zwetsloot et al 2015.

2.3 *Main findings*

The survey results are relatively similar for managers and workers, but managers had significantly higher ($p < 0.001$) average scores than workers on 10 of the 11 dimensions.

The survey results showed both organizational and individual commitment to ZAV were very high (for all respondents combined 3,39 on the scale from 1–4). These high commitments were confirmed by the interviews. It is likely that the high commitment is the main driver for long-term safety improvements.

The survey also showed the importance of safety communication, especially of management safety communication. Important were specific ZAV or safety promotion programs, constant and updated communication on functional tools, and effective supervisor communication. Successful communication must ensure 'relevant' information to various organizational levels, and allow for 'decentralized' initiatives.

There were four scales on safety culture. Generally the scores were high (above 3) but significantly lower than for commitment. There were high survey scores on management safety priority, safety empowerment and safety justice, but also relatively large differences between manager and worker survey results, especially for 'safety justice' and 'empowerment'. Workers also had relatively much lower ratings of management safety priority than managers had. This pattern is similar to what is seen in other safety perception surveys (e.g. the NOSACQ 50).

As the PEROSH ZAV survey comprises a number of items form the Nordic Safety Climate Questionnaire, the results for safety culture could be compared to the findings with the NOSACQ-50, which consisted of a total of 30,839 responses from 203 frontrunner companies (including an unknown number that are also committed to ZAV).

The ZAV companies had a more mature organizational safety climate where workers perceived their managers/leaders to higher prioritize safety on a daily basis and to be more competent in dealing with daily safety issues. Also, managers were better at creating an open atmosphere for communicating about safety, ensuring that everyone has necessary safety information and empowering workers to take part in discussions and decisions regarding safety issues. The ZAV companies also had to a higher degree a 'no blame' (just) culture.

The interviews clarified among other things, that proposals for safety improvements were rather common, but that it was essential that workers saw that they actually had *influence* on safety and that their opinions and suggestions really mattered.

The average scores for safety learning were also high (above 3,0), but there were 7 companies with averages below 3. Clearly there were substantial differences between the participating companies in this respect. Important success factors were top management support, an 'open atmosphere', systematic communication and dialogue on incidents, and a focus on things that go right.

The qualitative parts of the research clarified that in many ZAV committed companies, there are broader commitments to zero than ZAV (including zero defects, zero greenhouse effect, zero tolerance to unacceptable behavior, zero economic waste = lean, etc.). The relevance of ZAV for health promotion was shown in the three German companies (average score 3.11): ZAV tends to impacts positively on health promotion and the prevention of work-related disease. The Finnish companies emphasized the importance of ZAV strategies for developing wellbeing at work. It was also clear that broadening ZAV to include the prevention of ill health (zero harm) was identified as a future challenge in several companies, where this currently was not yet the case.

Commitment to Zero Harm should in principle imply the prevention of work-related diseases and the promotion of wellbeing at work (Zwetsloot et al 2017a).

Before elaborating on the potential synergies that Vision Zero can trigger between safety, health and well-being, it might be useful to look at some general characteristics of good implementation. Table 1 presents some key characteristics, but also pitfalls in this respect.

Table 1 shows once more, that commitment to Vi-sion Zero is a process whereby leadership is im-portant. For using innovative and learning

Table 1. Pitfalls when considering Vision Zero.

Vision Zero used inappropriately	Vision Zero used appropriately
Applying Vision Zero as a **target** and making people accountable for realizing it (perhaps even strengthened by economic incentives)	Vision Zero is a **process** that requires commitment from all leaders and workers in an organization
Focusing strongly on incident rates (and other lagging indicators)	Using leading indicators
Assuming that more safety rules, management systems and behavioral control will help to go from good to excellent safety performance	Focus on leadership, being innovative and promoting (collective and individual) learning
Assuming that one approach is able to improve different types of safety (e.g. process and personal safety)	Using a variety of approaches and adapting them where appropriate

Source: Zwetsloot et al 2017a.

approaches it is necessary to use leading indicators and that a variety of approaches is likely to be needed. The table also shows that Vision Zero can be used inappropriately, and recently an empirical study was published showing this that is not only theory (Sherratt and Dainty, 2017). It is thererfore important realize that commitment to Vision Zero implies much more than a written commitment or just following standard good practices. It is important to explore innovative perspectives and develop a learning culture.

Zwetsloot et al. (2017c - for Vision Zero, addressing safety health and wellbeing) and Zwetsloot et al (2017a - for the Zero Accident Vision) thereby distinguish six 'innovative perspectives', and clarified the main implications for safety health and wellbeing at work.

These innovative perspectives are: (1) Vision Zero as a commitment strategy, (2) Vision Zero as a way of doing good business, (3) the innovation perspective, (4), the development of a prevention culture, (5), the ethical perspective which is linked to corporate social responsibility, business ethics and good employership, and (6), networking and co-creation.

These six perspectives are not fully independent. One could argue that all six perspectives are important for a commitment strategy or for a prevention culture. The latter is hereby understood as: a culture wherein the health and safety of each individual are valued; and where there is a strong commitment to promote health and safety and to prevent all occupational accidents and work-related diseases. A Prevention culture is characterised by the integration of the value of health and safety in all activities, and strong patterns of prevention and promotion.

Synergies between the six innovative perspectives are certainly possible. Jointly they offer a range of potentials for improvement of safety, health and wellbeing at work, which can be explored in practice. These perspectives also offer interesting perspectives for research projects on the implementation of Vision Zero.

There are also important opportunities for synergy between the prevention of accidents and promotion of safety on the one hand, and the promotion of wellbeing at work and the prevention of psychosocial risks on the other hand. This is addressed in Zwetsloot et al. (2017a), and includes the control of deviations in work processes, common challenges due to the 'changing world of work' (e.g. the impact of continuing cost reductions), improving accuracy and reducing human error, proactive approaches to new developments (e.g. reorganizations and outsourcing, job insecurity), 'fitness for the job', dealing with interfaces in the production process, genuine care for the employees, fatigue and safety, work organization and safety, and the impact of job demands and resources on safety outcomes (the latter being significant according to a meta-analysis by Nahrgang et al. (2011).

3 CONCLUSION

The implementation of the Zero Accident Vision is not a subject that is often addressed in research so far. This paper shows that when ZAV is applied appropriately it implies a range of challenges and innovative perspectives. These should be further explored in practice as well as research.

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Dialogue in asymmetrical power relations—modern safety regulation?

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ABSTRACT: The purpose of this paper is to explore power, sensemaking and identity construction within a regulatory regime in the petroleum industry that emphasises dialogue and trust as a desired and prioritised mode of working. Based on a qualitative study, the analysis documents that dialogue becomes an arena for sensemaking among unequals, and that the regulator employs the process of identity construction as a means to promote regulatory compliance.

1 INTRODUCTION

Exploration and production of oil and gas are complex, costly and potentially hazardous and pose risks to health, safety and environment (HSE). It is important to safeguard that operations are carried out in a safe way throughout the whole petroleum industry life cycle, from exploration, drilling through development and operation to cessation and removal (Lindøe et al. 2014). Accidents, such as the capsizing of the Alexander Kielland flotel in 1980, which caused the death of 123 workers, and the blowout and fire on the Deepwater Horizon drilling rig in the Gulf of Mexico in 2010, which killed 11 people and caused the worst recorded spills, are reminders of the risks involved and the fatal and devastating consequences when things go wrong. A regulatory regime that investigates and addresses specific problems and stimulates the players to improve performance and prevent accidents, is important in ensuring offshore safety.

Power is embedded in the task of regulatory bodies, and regulatory regimes often follow a model of control and command, where they conduct inspections and issue sanctions in cases of non-compliance to rules (Hood et al. 2001; Hopkins & Hale 2002). The Norwegian regulatory regime in the petroleum industry has received international attention due to its specific characteristics (Hart 2007; Thurber et al. 2011): The regulatory authorities often use “soft” forms of reactions in case of violations. Besides, they claim that dialogue and trust between stakeholders are crucial, and tripartite collaboration between employers, employees and government is flagged up as a cornerstone for a high safety level (Bang & Thuestad 2014; Forseth & Rosness 2015). Dialogue, trust and tripartism are also pivotal in the “Norwegian Model” in working life and welfare state in general (Bungum et al. 2015).

2 CONTEXT

When the oil adventure started in the 1970s, Norway had little experience but the government set down some important principles emphasizing national control with all activities on the Norwegian continental shelf (NCS) (White paper 76, 1970–71). Initially the regulations of safety and the working environment were mostly based on adapting prescriptive regulations, checklist-oriented inspections and government-based approval (Bang & Thuestad 2015: 244–46). The Ekofisk Bravo blowout in 1977 and particularly the investigation after the Alexander Kielland disaster in 1980 focused attention on weaknesses with the traditional regulatory approach, and had major political and administrative consequences. From 1985, there was a paradigm shift and a new regulatory regime was introduced; a system of government-enforced self-regulation or internal control with risk assessments and principle based requirements as basic elements. A goal-setting and risk based approach was introduced, where the operators became the party principally responsible for interpreting the goal-based requirements and monitoring their own compliance with the regulations.

According to their website, The Petroleum Safety Authority (PSA) supervises all players in the Norwegian oil and gas industry (“Role and area of responsibility”, www.psa.no). The PSA’s supervisory responsibility embraces oil and gas activities on the whole NCS, at eight facilities on land, and with associated pipeline systems.

It covers operators, licensees, contractors and vessel owners, and the whole petroleum-industry life cycle from exploration drilling, development and operation to cessation and removal.

The petroleum industry is powerful, and oil and gas resources are an important part of the global energy system. The interplay between power and sensemaking became salient in a period around the year 2000 (Rosness & Forseth 2014), when a controversy among stakeholders concerning the safety level on the NCS threatened to disintegrate the established tripartite collaboration on HSE. Union representatives claimed that HSE conditions had deteriorated due to cost cutting, whereas industry representatives claimed that HSE conditions had never been better. After the intervention of the political and regulatory authorities, a more cooperative climate and a convergence of sensemaking gradually emerged from mid-2000. The tripartite collaboration was revitalised and tripartite arenas were established such as Safety Forum and Regulatory Forum. A major research project was initiated to help build a common perception of the risk level in the industry. We have argued that the capacity and willingness to enrol new actors, such as regulatory and political authorities and mass media, was a prerequisite for the revitalisation of tripartite collaboration. The patterns observed seem compatible with Weick's (1993) proposal of a mutual influence between sensemaking processes and organisation. In the initial phase, disintegration of collaboration reinforced and was reinforced by the failure to reach a shared understanding. In the revitalisation phase, the new collaborative arenas facilitated joint sensemaking, whereas collaboration was facilitated by enrolling the research community to help build a common perception of the risk level. The ability to engage in a conflict when HSE was under pressure, and the capacity to subsequently join forces and revitalise collaboration were equally important aspects of the robustness of the regulatory regime. A process of sensemaking through "boxing and dancing" supported HSE improvements (Rosness & Forseth 2014).

3 SENSEMAKING AND CRITICAL SENSEMAKING

Sensemaking is a perspective associated with research that is interpretive, social constructionist, processual and phenomenological. Karl E. Weick introduced the term 'sensemaking' to organisation studies and his seminal paper on 'Enacted sensemaking in crisis situations' (1988) influenced crisis management and sensemaking research. Sensemaking is a lens to comprehend and theorize how people appropriate and enact their 'realities' (Brown et al. 2015, Maitlis & Christianson 2014, Weick 1993). There is no single agreed definition of the concept, but there is a growing consensus that sensemaking refers to those processes by which people seek to understand and give meaning to *situations or events that are ambiguous, equivocal or confusing issues or events* (Brown et al. 2015:266, Colville et al. 2012). An important aspect of sensemaking is understanding how different people assign different meanings to the same event. In addition to the ongoing nature of sensemaking, seven interrelated characteristics are involved: identity construction, retrospection, focus on and by extracted cues, plausibility rather than accuracy, enactive of the environment and social (Weick 1995; Mills et al. 2010:185). Sensemaking has attracted attention and become widely used in a variety of areas. Maitlis and Sonenshein (2010:552), in their review of the sensemaking literature, expand the analysis beyond merely looking at sensemaking and crisis to sensemaking in times of turbulent context and organizational change. These are also situations characterized of ambiguity, confusion and disorientation and may violate expectations (Maitlis & Christanson 2014, Weick 1988).

In times of transition and uncertainty, power and sensemaking become salient (Weick & Sutcliffe 2007). Power is a key concept within the social sciences and there exist a range of frameworks. As authors such as Clegg (1993) and Gabriel (2000) emphasise, narratives provide us with insights into the nature of organizations, power relations within them, and the experience and sensemaking of their members. The accounts that dominate in organizations and the practices that become accepted are a result of negotiations that take place in structures where some voices are privileged over others (Maitlis & Sonenshein 2010). The sensemaking literature, however, has given inadequate attention to power and political processes even if power provides a context for sensemaking (Maitlis & Christanson 2014). It is not until recently that it has been unpacked in this strand of literature how other groups of employees, such as middle managers and employees, make sense of changes that differ from top-level management. In order to grasp who gives sense and who cedes sense under what conditions, it is important to explore narratives from different stakeholders. In this paper, we pay particular attention to how the use of dialogue as a regulatory strategy unfolds in a context of power asymmetries related to the regulatory role.

The sensemaking perspective has been criticized for an under focus on issues such as power and context, and Mills et al. (2010:182) propose a heuristic that takes into account missing elements while operationalizing (critical) sensemaking as an analytical tool for understanding organizational events. In their outline of a critical sensemaking approach Mills et al. (2010) seek to get a better grip on how sensemaking is related to power relations in the broader social context. They emphasise the centrality of *identity construction*, i.e. how people answer questions such as "who are we?" and "how do we do things?". Mills et al. (2010) suggest that "individuals with more power in organizations may also exert more power on the sensemaking of organizational members". We propose that the notion of identify construction and the idea of exerting power on others' sensemaking may also be applied to interactions between organisations, such as between regulatory authorities and regulated enterprises. This opens for the possibility that the regulatory authorities may offer an industry as a whole and each of its companies an attractive identity that they can maintain and strengthen by complying with the regulations and cooperating with the regulatory authorities.

There is a limited body of work on sensemaking and institutions (Maitlis & Christanson 2014: 108). We are interested in (1) the sensemaking processes that take place within the context of a dialogue based regime and the encounters between regulator and the regulated, and (2) how the stakeholders make sense of these processes of sensegiving and sensemaking, e.g. the various views on how the dialogues actually function and how they ideally should function:

1. How do the regulatory authorities give and make sense of dialogue based regulation?
2. How do different stakeholders in the petroleum industry make and take sense of dialogue based regulation?
3. How do different stakeholders talk about the interplay of power and sensemaking in encounters between the regulator and the regulated?
4. To what extent and how do the regulatory authorities use the process of identity construction as a means to promote regulatory compliance?

4 DATA MATERIAL AND METHOD

In the analysis, we have adopted an inductive, interpretative research methodology. Several sets of data material form the empirical basis of our analysis. First, we draw on a strategic selection of texts and excerpts from publications from the PSA Norway and their website ptil.no. Second, we got access to data sets from an expert committee on inspection strategies and HSE regulation appointed by the Norwegian Ministry of Labour and Social Affairs (Engen et al. 2013, 2015). We re-analysed the raw data from focus group interviews gleaned from a strategic sample of stakeholders from government, major operators, new licensees, drilling entrepreneurs and suppliers. The data collection was carried out from March to June 2013, and a follow up interview was accomplished in May and June 2014. The focus groups consisted of a strategic choice of informants: officers from five different divisions at the PSA, two groups of managers and an individual interview with the Director-General, and authority coordinators, operations managers, safety representatives and shop stewards in the enterprises. The topics discussed included: 1) Recent changes and future challenges for HSE work, 2) regulatory strategies and practices, and 3) supervisory policy instruments. Third, we did a follow-up focus group interview at the PSA with four senior principal officers in April 2016. Our focus group interview was narrower in scope with four main topics: the voices of the regulator in accidents reports (Rosness et al. 2017), supervision (Dahl et al. 2017), dialogue based inspection and impacts of the recession. An overview of the focus group interviews is presented in Table 1.

Finally, we draw on a portfolio of joint research projects on regulation of HSE in the oil and gas industry funded by The Research Council of Norway (no. 183251, 233971).

The analysis consisted of multiple readings of documentation and interview transcripts. The process was very 'hands on' with regard to grasping local narratives. Inspired by the literature on sensemaking, we generated themes recurring across categories of informants, first tracking sensemaking, sensegiving and sensetaking. Later, we went back to the data material searching for processes of identity construction. A selection of quotes is presented verbatim to make the sensemaking of the actors come alive for the reader, and present enough raw data to make the analysis a convincing read.

For reasons of anonymity, we do not reveal the names of the companies except for the public institutions. We try to be as accurate as possible when it comes to displaying positions and still retain the anonymity of the interviewees and the companies. The analysis is delimited to the relationship between government (the Ministry of Labour and Social Affairs and the PSA) and major operators due to space limitations.

Table 1. Cases, focus groups and interviews.

Categories and organizations	Focus groups interviews	Persons
The PSA and The Ministry of Labour and Social Affairs	9	32
Major operators	8	24
New licensees	11	18
Drilling entrepreneurs	2	6
Suppliers	3	9
Sum 2013	33	89
Additional interviews PSA 2014	3	12
Our interviews PSA 2016	1	4
Total	37	105

5 MAKING SENSE OF DIALOGUE BASED REGULATION

The Norwegian regulatory regime in the petroleum industry may seem as a puzzle, because it stands out as open and with "soft" forms of reactions in case of violation. Informants from the Ministry underscored that this regime differs from a traditional control and command model, the PSA has a very broad definition of regulation and that everything they do is labelled supervision. The informants were impressed with how the Norwegian regulatory regime within the petroleum sector seems to work and what it has achieved:

> *The PSA has a distinct role in the industry. Everybody knows who they are, and what kind of work they do. Seemingly, they seem to have a tremendous impact in many areas. At the same time, in the press and other[sources], stories are popping up that are not so good, reports on aging installations where there are big problems. There have been some accidents...* (I3, Ministry)

This ambivalence was also related to other factors: the entry of new small players on the shelf and risks associated with search and exploration of new areas north in Norway with harsher environments. Cues and stories about incidents and near misses made the informants start asking questions about changing conditions and emerging risks:

> *To put it bluntly, if there is an accident on the Norwegian shelf – would the regulatory practice of talking a lot to those "up there" stand the test?* (I3, Ministry)

As we interpret it, this informant alluded to the dialogue based practice of the PSA in contrast to more inspections and formal sanctions. Their viewpoints on the regulatory regime were summed up in phrases such as: *Impressed, but a little worried….* (I2, Ministry). *In doubt…* (I3, Ministry). Because if something were to happen, the consequences are dramatic: "*there is much money, much drama, and serious consequences*". (I1, Ministry). Overall, the informants concluded that that seemingly, the Norwegian regulatory regime is solid, trustworthy and works well, but raised questions whether the infrequent use of formal sanctions is sufficient in light of changing circumstances and emerging risks.

6 MAKING AND GIVING SENSE OF DIALOGUE BASED REGULATION

The PSA Norway describes themselves as an «independent government regulator with responsibility for safety, emergency preparedness and the working environment in the Norwegian petroleum industry», according to their website ("Supervision", www.psa.no). The supervisory regime builds on the view that a regulator cannot "inspect" quality into the petroleum sector. In colloquial terms, the PSA is *both guide dog and watchdog for the industry* ("About us"). The PSA also underscores that they pursue risk-based regulation, but that it is the «*companies' own responsibility to monitor that they comply with laws and regulations*». There is an interesting tension about power and responsibility here, and we will come back to that later in this section. The statement also carries implications concerning the identity of the players in the petroleum industry, because it presumes that they are capable of monitoring their own compliance with laws and regulations and that they are motivated to comply.

In the Norwegian regulatory regime offshore, the PSA advocates a broad definition of what they do:

> *Supervision embraces much more than inspections of offshore facilities and land-based plants. This term refers to <u>all contact</u> between us as the regulator and the regulated object* [our underlining]. ("Supervision", www.psa.no)

This citation can be seen as a legitimation of their strategies and activities. It also illustrates that the Norwegian regulatory regime transcends a traditional control and command model of regulation by underscoring the importance of dialogue and interaction. The encounters between regulator and the regulated take on many different forms, and the supervisory activities include ("Supervision"):

- meetings with the companies
- acquiring data about accidents and incidents
- considering company development plans
- applications for consent to conduct various activities, and
- investigating accidents.

A general principle in their interaction with companies is that both management and workers' representatives (union officials and safety representatives) shall be present at meetings. Accidents investigation reports, reports from inspections and correspondence from the PSA to the players are publicly open and published on the PSA website. This policy is in accordance with the principle of free access to public records, but is also implies that the PSA can have an influence on the reputation of the regulated companies, and thus on their identity. We were told that PSA employees are very careful not to abuse this power, and that accident investigation reports are therefore submitted to a rigorous quality control procedure.

The PSA characterises dialogue as a prioritised mode of working in an article that was published both as part of the annual report "Safety—status and signals 2008–2009" and as a separate article at the PSA web site (PSA 2009):

Dialogue is a key element in contacts between the PSA and the many different players on the NCS. Pursued continuously, such conversations help to ensure regulatory compliance. This approach holds a key place in the PSA's supervisory strategy as a desired and prioritised mode of working. The discussions are respected by everyone concerned, and established as a basis for supervising that petroleum activities comply with the regulations.

Besides, dialogue is also presented as a form of reaction to violations:

As a form of reaction to violations, dialogue is utilised primarily for minor breaches of the rules or when the position is likely to be regularised in the near future. More formal and statutory responses available to the PSA … include orders, halting activities and coercive fines. The PSA assesses in each case which sanction will best return the relevant activity to compliance with the regulations. … Sanctions can be escalated, with stronger reactions utilised if the initial response fails to have the desired effect.

This introduces power asymmetry into the PSA's conception of dialogue. The PSA may impose sanctions on the other part if it does not find the outcome of dialogue adequate. Dialogue becomes an arena for sensemaking among unequals. The use of dialogue as preferred means of reaction gives the companies involved an opportunity to defend their identity as willing and capable to improve when violations are detected. A failure to improve would not only lead to stronger formal sanctions from the PSA, it could also threaten the identity of a company as a serious player. In some cases, the reputation of the whole industry could be at stake.

The PSA prefers to use the concept of system-based orientation instead of compliance (with connotation to individual actions). Dialogue is the most widely used tool, and the PSA seldom issues fines and sanctions according to their homepage and our interview data. The regulator regards it as the best tool for influencing the regulated companies. Besides, it gives the companies a possibility to give feedback to the authorities, and it contributes to increased learning for both regulated and the regulator. Underlying this perspective is a general trust in the companies and their will to improve safety. This was emphasized in our focus group at the PSA: *We have trust in the companies, but it is not blind or naïve* (I2, PSA). Principal officers at the PSA elaborated on their way of dialoguing and summarized it as *formalized, restricted and ritualized* and they underscored that the dialogue is never informal.

No one gives away everything about themselves. It is a ritual where both parties have their specific roles to play. And there are some limitations to this [interaction] (I2, PSA).

This illustrates that the PSA has a specific interpretation of the term dialogue and that it is ritualized in practice, where both parties engage in impression management without revealing everything about themselves. Thus, the term dialogue within this context, deviates from a traditional interpretation of informal interaction between two (equal) parties.

Another informant followed up by explaining why this kind of dialogue is important: *The aim of dialogue is to ensure better compliance or else we could have relied on control* (I4, PSA). The informants elaborated on this statement by explaining that a narrow focus on individuals contributes very little to risk reduction. What is essential in order to improve safety was summarized in these words: *It is all about structural [aspects], planning of work operations, organizational aspects, MTO* [man, technology, organization] issues (I1, PSA). This shows that one raison d´être for the dialogue based regime, is the pursuit of systemic factors and their impacts on safety. In an analysis of a strategic selection of accidents reports (Rosness, Dahl & Forseth 2017), we found that event sequences descriptions were mostly "de-individualized", i.e. individuals did not figure as grammatical subjects. Nonconformities were framed as deficiencies of the safety management system rather than individual violations.

The PSA may impose sanctions on the other part if it does not find the outcome of dialogue adequate and discover irregularities or violations.

As a form of reaction to violations, dialogue is utilised primarily for minor breaches of the rules or when the position is likely to be regularised in the near future. More formal and statutory responses available to the PSA … include orders, halting activities and coercive fines. The PSA assesses in each case which sanction will best return the relevant activity to compliance with the regulations. … Sanctions can be escalated, with stronger reactions utilised if the initial response fails to have the desired effect. ("Safety—status and signals 2008–2009" and as a separate article at the PSA home page, 2009).

Sanctions can be escalated if the dialogue does not contribute to improvements. One of our informants framed it this way: *We employ everything from smile to pistol—the whole scale* (I3). The regulated companies can exert power and resistance by postponing, withholding information, delaying implementation of measures or refusing to deliver internal documents.

In addition to conducting inspections, the PSA follows up cooperation between workers and management at the individual workplace, and promotes tripartite collaboration between employers, employees and authorities. *Two important arenas have been established for such tripartite collaboration in the petroleum sector—the Regulatory and Safety Fora.* In these arenas, the parties *can join forces in a constructive collaboration on improvements, including for safety and the working environment—an asset all the parties say they want to preserve and develop* ("the-norwegian-model", www.psa.no). For the PSA, tripartite collaboration is another cornerstone in their regulatory regime and important in making the Norwegian oil and gas industry a pioneer industry as regards HSE, both on a national and international level.

In the next section, we will explore how stakeholders from operators interpret and make sense of dialogue based regulation and the interaction with the PSA.

7 MAKING AND TAKING SENSE OF DIALOGUE BASED REGULATION

The informants from the operators were positive to the importance of dialogue in the regulatory regime, and some emphasised that this gave the companies ample opportunity to amend and correct issues and in this way, avoid a sanction and publicity in the media. Others claimed that the widespread use of dialogue and soft use of instruments, were responsible for weakening the power of the PSA. The encounter between the regulator and the regulated are based on mutual trust. One representative underscored on behalf of the workers that the PSA always announces a visit to an installation beforehand, and this affects how they make their preparation in-house:

> *For every time there is going to be an encounter with the PSA, it is just like having ten mothers' in law come visiting, you clean up in every corner—it does not reflect every day* [operations]. (I3, Safety representative, Operator)

It is interesting how the safety representative used "ten mothers' in law" as a metaphor for the PSA, and how he underscored that they "clean up in every corner" in advance. As a result of window-dressing, the representatives from the regulator get to see a polished façade. Shop stewards were concerned about lack of time and resources at the PSA to fulfil their mission. They also told stories on how, in response to sanctions from the PSA, their enterprise had exercised pressure by challenging rules, bypassing the PSA and sending lawyers to talk with people from the Ministry of Labour and Social Affairs.

A manager was critical to the way of doing dialogue because it is "more about talking *to* rather than *with* each other". He elaborated on this statement:

> *…We see that we can improve the dialogical aspect of these dialogue meetings. …there tends to be a lot of power point presentations from both sides rather than a dialogue to understand each other's point of view.* (I1, Operations Manager, Operator)

From his point of view this kind of power point interaction could end up as impression management rather than increase understanding. He also claimed that the PSA sometimes went too far in their exercise of power, such as asking for investigations without an order. He told a story about how the PSA had wanted to get access to the Board and the Board of Directors in order to get more detailed information. This request had been declined and one reason was unwillingness to share commercial details. This is clearly an example of resistance on behalf of the regulated. On the other hand, they had on occasions accepted to do investigations when the PSA asked for it, even without an order, *just to get peace*. Another Operations Manager commented on the content of the dialogue:

> *«…To have an informal dialogue where we really can talk openly about our challenges without risking that it comes back as a regulatory activity from the PSA—is used against us.»* (I3, Operations Manager, Operator)

He underscored the informal side of a dialogue in contrast to the formalized dialogue advocated by the PSA. He went on to voice critical comments regarding how the dialogue functions in practice and desired a dialogue without risk of sanctions. This is an example of differences in sensemaking and sensetaking of dialogue based regulation. Besides, it illustrates that the dialogue is embedded in power relations, and both parties enact their role accordingly. Informants from the PSA also emphasised that there is a difference between supervision which is the most formalized encounter, and other meetings where there is more of an exchange of viewpoints between regulated and the regulator. Our informants in the focus group, however, drew the conclusion that the PSA never involves in an informal dialogue, there is always a formal interface. This division does not seem to be totally clear for the regulated as illustrated in the quotes.

Tripartite collaboration between companies, unions and the authorities is one important aspect of the dialogue based regime. Both managers and employees in our sample said that the PSA facilitates well for tripartite collaboration through arenas where different stakeholders can come together and share their viewpoints. One manager was concerned about what he felt was a drive and pressure towards consensus:

> *Some think that if we disagree, these arenas do not work… I mean that disagreement is a proof of the opposite because we have different roles to play. Maybe there is too little discussion and that there*

should be more of it instead of striving for consensus. (I3, Operations Manager, Operator)

In general, the informants were positive towards (tripartite) collaboration between the stakeholders. Tripartite arenas, however, can also end up as nodes of power (Clegg 1989) where some viewpoints are taken for granted or gain hegemony, and some participants experience a pressure towards consensus. In line with our previous arguing (Rosness & Forseth 2014, Forseth & Rosness 2015) – more "boxing and dancing" among the participants can be a resource for improvements and increased safety level.

8 DISCUSSION

The PSA preaches and practices dialogue, but the dialogue takes place in a context of asymmetric power relations, where the regulator can impose formal and informal sanctions on the regulated if it does not find the outcome of dialogue adequate. Dialogue becomes an arena for sensemaking among unequals. Some regulated players seem to accept this asymmetry without reservations, whereas some operators employ juridical arguments to bound the space of manoeuvre for the regulator. We noted ambiguity and divergent views of different stakeholders concerning how the dialogue based regime works and how robust it is. The infrequent use of formal sanctions is controversial, and some stakeholders advocated more execution of power through inspections. This viewpoint undermines the philosophy of the current regulatory model with emphasis on systemic factors, self-regulation and dialogue. We also found divergent views concerning how much tension and conflict such a regime can handle.

Our analysis illustrates that the PSA employs control over the identity of themselves and others in a systematic way as a means of power. They offer the petroleum industry and each company an identity as a serious player with the ability for self-regulation and learning. Besides, we noted that they offer and demand from the major operators that they play a special role as role-model and driving force. The PSA is also conscious about their own identity and dissociates from a command and control role that is not compatible with the identity they want to offer the industry and the players. The way the regulatory regime functions today, seems to be based on the PSA using the control over the identities of the companies as a more effective source of power than formal sanctions such as orders or coercive fines.

Ambiguous HSE issues can be resolved within a context of various forms of dialogue and collaboration characterised by ambiguities and asymmetric power relations. The PSA and the regulatory regime are currently under pressure: The Norwegian petroleum industry has been dominated by Statoil and major international operators, but new minor players have entered the NCS. There is also a pressure toward harmonizing national and international rules and standards. The Norwegian government has opened up for oil exploration in harsher environment further north, but there is currently a controversy regarding inclusion of new areas. Besides, the fall in oil prices led to a recession in the industry and downsizing in companies. These changes could challenge the current dialogue based regulatory regime. However, the experience from the controversies around year 2000 suggests that this model thrives on tensions and ambiguities, and "boxing and dancing" among stakeholders (Rosness & Forseth 2014).

The sensemaking perspective and the methodological entry of combining public documents and interviews with different stakeholders in focus groups, have enabled us to map how informants give sense, make sense and take sense of the Norwegian model of regulation of HSE in the petroleum industry. Early accounts of organisational sensemaking emphasised ambiguity and uncertainty as occasions for sensemaking (Weick 1995). Controlling others' identity as a means of power, provides a key to interpret modern safety regulation and understand an unorthodox regulatory regime.

9 CONCLUSION

Our study has focused on principles and practices of dialogue based regulation and encounters between regulator and regulated. The philosophy of the Norwegian regulatory regime in the oil and gas industry, how it works and what keeps it together, are influenced by the mind-set of the Norwegian model in working life and welfare state. The analysis shows that the informants were in favour of this kind of dialogue based regulatory regime, but there were clearly tensions and ambiguities. The stakeholders gave sense, made sense and took sense of dialogue based regulation and the encounter between regulator and regulated in different ways. Dialogue becomes an arena for sensemaking among unequals. The regulator can execute power and impose sanctions. More importantly, our analysis has shown that the PSA employs the process of identity construction as a means to promote regulatory compliance. The regulated companies, however, can exert power and resistance by withholding information, delaying implementation of measures or refusing to deliver internal documents.

The way the regulatory regime functions today, seems to be based on a premise that the PSA can use the control over the identity of the companies as a more potent power base than formal sanctions. It is, however, a question to be debated how this regime will work under changed framework conditions, e.g.

the fall in oil prices and the recession, the pressure toward harmonizing rules and standards, or with the influx of new players on the Norwegian shelf. From a formal point of view, the regulator can apply stronger sanctions. This may also cause the regime to change its character, and give up on the opportunity to play on identity in the same way as today. Regarding future research, it would be interesting to analyse additional sources of communication from the regulator to the industry, such as letters and investigation reports. To compare and contrast the sensemaking and sensetaking of other players, such as new licensees, drilling entrepreneurs and suppliers, would be another option.

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The future of health and safety legislation and the role of different stakeholders in occupational safety and health legislation

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ABSTRACT: This study is the first part of a broader nationwide survey and presents the results related to the perceptions of the top management of the Department of the Labour Inspection in Cyprus. Findings suggest that OSH legislation must be simplified in order to facilitate not only the enforcement by the Inspectors but also compliance of the duty holders. The effectiveness of OSH legislation could be enhanced with further involvement of stakeholders since they are the ones who have direct communication with duty holders. Additionally, specialized training for Inspectors, improved internal guidance and regular meetings between Inspectors could also add value to the effectiveness of OSH legislation. However, it is of crucial importance that duty holders are able to learn the importance of complying with OSH legislation and the benefit on investing in OSH.

1 INTRODUCTION

Occupational Safety and Health (OSH) legislation is directed to providing a safe and healthy workplace for all workers by setting and enforcing appropriate regulations. Employers and employees must take part in the formation of a safety culture and comply with them. Legislation should be focused, clear, easy to understand and adaptable to each of the involved parties.

OSH legislation must be seen by involved parties as guidance or an effective tool for the implementation of an effective safety management system in the workplace.

The aim of this study is to examine the effectiveness of the enforcement of OSH legislation in workplaces on the reduction of occupational accidents, diseases as well as dangerous occurrences.

The main objective is the assessment of the impact of the different stakeholders on OSH Legislation:

- formation,
- amendment and
- development

Additionally, the study examines the perception of the involved parties/experts on the easiness to comply with it.

The fact that OSH Legislation in Cyprus is harmonized with relevant European Directives, the results of this study reflect the European OSH legislation as well.

This paper presents empirical findings from a study that has identified the perception of OSH Legislation concerns of the involved parties/experts (e.g. Employers, employees, stakeholders, Inspectors of the Department of Labour Inspection, Safety Officers, OSH Consultants, etc.). Data (personal interviews) have been collected from the top management of the Department of Labour Inspection from all over Cyprus.

The study examines how comprehensive it is for the affected parties to comply with or to enforce the existing legislation. Questions such as: "How easy it is for employers to understand and comply with the provision of the OSH Legislation on the adoption of new technologies" will be answered. Moreover, suggestions on the improvement of the effectiveness of OSH legislation are presented.

The Cypriot Safety and Health at Work Legislation consists of three main documents:

- Cypriot Legislative Documents,
- European Legislative Documents, and
- International Legislative Documents.

European Legislative Documents include the Regulations, Directives, Decisions, Recommendations and in general "acquis communautaire" and after the application of Cyprus to become a member of the European Union, an active policy to harmonize the Cyprus Legal Framework with the "acquis communautaire" was undertaken. The European Union Directive 89/391/EC constitutes the common legal base of OSH legislation for all European Union Member States. The main principle of this Directive is the protection of worker's health and safety and therefore the employer has the obligation to ensure worker's safety and health in every aspect which is related to work whereas the worker is obliged to follow the instructions of the employer and report potential hazards.

International Legislative Documents are based on International and European Instruments such as UN Conventions, European Social Charter and ILO (International Labour Organization).

According to the Legislative Documents that are accessible through the Department of Labour Inspection's website, there are 131 Legislative Documents, 64 Cypriot Legislative Documents (48.9%), 56 European Legislative Documents (42.7%) and 11 International Documents (8.4%).

1.1 *The process for the preparation of occupational safety and health legislation*

- Initial drafting by the Department of Labour Inspection
- Internal consultation
- External consultation from the Ministries and other Governmental Departments/Services —discussions with Social Partners and other Stakeholders—comments from the Pancyprian Safety Council.
- Labour Advisory Board approval.
- Legal venting by the Legal Office.
- Council of Misters approval.
- House of Representatives, Labour Committee voting.
- Publishing in the Official Gazette of the Government.

1.2 *Labour advisory board*

The Labour Advisory Board consists of the following members:

- the Minister of Labor, Welfare and Social Insurance or his representative as the President
- 3 representatives of the Federation of Cyprus Employers and Industrialists
- 3 representatives of the Cyprus Chamber of Commerce and Industry
- 3 three representatives of the Pancyprian Labor Federation
- 3 three representatives of the Cyprus Confederation of Workers
- 1 representative of the Democratic Labor Federation of Cyprus

The responsibilities of the Council are the following:

- Advises the Minister of Labour, Welfare and Social Insurance -
  - On all labour issues and the promotion of labor peace
  - On issues that employers and employees have a common interest
  - On ways and means of encouraging the study by both employers and employees on all issues that affect the progress and prosperity of the industry
- Makes recommendations and suggestions on labour legislation

1.3 *Pancyprian Safety Council*

The Pancyprian Safety Council was established on the 9th of March, 1965. At that time the Council's Chairman was the Minister of Labour and Social Insurance and its main aim according to its statute was "to assist, provide information, guidance and direction to those involved in the prevention of accidents and the assurance of safe working conditions and habits".

Later on, the Pancyprian Safety Council was regulated by the Safety at Work Law of 1988 and since 1996 by the Safety and Health at Work Law.

The Council consists of 14 members—non-governmental organizations, Scientific Technical Chamber, the Cyprus Safety and Health Association, trade unions of employers and employees and governmental departments. The President of the Council according to the provisions of the Safety and Health at Work Law, is the Chief Inspector and Director of the Department of Labour Inspection.

The responsibilities of the Council are the following:

- Advises the Minister on issues of accident prevention.
- Develops, disseminates & maintains those activities that will affect or create the conditions for improving the safety and health of workers and the public.
- Submits proposals or suggestions to the Minister for the measures to be taken and the best and most effective working methods to be followed for ensuring OSH of workers.
- Advises the Minister on drafting or revising Regulations based on the knowledge & experience gained from local conditions, international developments & technological progress.

2 LITERATURE REVIEW

2.1 *OSH legislation*

The need for reformation of EU Directive on OSH (89/391/EEC) is often debated, however there is very little research on the assessment of the effectiveness of the retrospectively ex post implementations of the existing EU Directives. The practical effect of OSH legislation is rarely assessed as well as what the regulator wanted to achieve and what happens in actual practice (Niskanen et al., 2012).

In many European Countries there is no specific legislation for several issues such as psychosocial risks. However, these risks could be considered as general risks and fall under the provisions of appropriate OSH legislation through which the duty holders are obliged to comply with (Toukas et al., 2015).

According to Toukas et al. (2015), as far as the psychosocial risks are concerned, the existing legislative framework does not clearly define the way that psychosocial risks should be assessed and managed. A fact that also has an impact on the way European Labour Inspectorates act. This makes the way of inspection non uniform and therefore there is a necessity of creating a common action framework so as to be able to guide European Labor Inspectorates towards a uniform holistic approach to tackle psychosocial risks at workplace. To achieve that a systematic training of the Labor Inspectorates is needed, as well as modification of the legal tools used by the Labor Inspectorates during the inspection, in order for the intervention of the inspector to be more effective. Furthermore, training of the employers and employees is also essential so as to be able to actively participate in OSH management.

The role of prosecution as a preventive measure for breaches of OSH legislation is debated. The debate is between the regulators concerning the efficacy of a deterrence approach, e.g. high fines, compared to compliance approach, where the organizations are encouraged to change attitude towards OSH (Schofield et al., 2014).

According to Baldock et al. (2006), inspections of regulatory officials are of most importance, however innovative approaches are needed. There is little research on whether inspections, citations and sanctions enhance OSH. Although prevention incentives are created with the enforcement of OSH legislation, legislation itself does not address the root causes of injuries and regulators are not at ease to punish and detect non-compliance. In many cases the cost of sanctions is much less than the compliance cost, therefore fostering trust and cooperation may have better outcomes (Tompa et al., 2007).

The employees of small enterprises are in higher risk while being at the workplace compared to the workers of large enterprises due to the fact that small businesses have limited resources and expertise and additionally is very difficult to be found by Inspectors. Small enterprises also reveal low awareness of legislative provisions (Arocena et al., 2008; Cagno et al., 2013; Boustras et al., 2015)

According to Viscusi (1979), the level of efficacy of job hazards regulations is critically connected with the economic incentives created whereas investing in work quality will eliminate the sanctions due to non-compliance.

2.2 *OSH legislation and stakeholders*

Trade Unions are playing an important role in the reduction of incidents at workplace and health and safety policy area is accepted broadly an in full consensus by all EU Member States.

In Cyprus Trade Unions organize short training courses with the aim to provide basic safety related skills to the workforce. Moreover, the employers' federation organizes training courses for health and safety officers that are employed by their members (Boustras et al., 2015).

2.3 *Legislation and safety culture*

Organizational culture consists of basic assumptions related to both the internal integration of the group and the external adaptation to the group's environment. Legislation is considered to be an external issue with which the organization must comply with and consequently is expected to influence safety culture. Although safety culture is difficult to be regulated in a direct way, however it consists of an opportunity so as the regulator to force the regulated to continuous actions in order to improve safety culture within the organization (Antonsen et al., 2017).

According to Antonsen et al. (2017), the International Atomic Energy Agency (IAEA) since a long time ago, had realized the necessity for a "strong safety culture" as far as nuclear industry's success and sustainability concerns and suggested to the regulator to introduce a general provision on management systems so as to fulfil expectations related to safety culture.

As far as safety culture oversight concerns, IAEA suggests three pillars. First, mutual understanding of what safety culture stands for, is of major importance in order to be able to communicate and promote safety culture. Second, conversations are important for sharing information and solutions as well as to clarify and allocate roles. Third, continuous engagement due to the regulators demands is crucial in the development of a strong safety culture.

The effectiveness of safety culture as regulatory concept is examined in a lot of publications. In some of them there is the concern whether the introduction of an intangible concept as safety culture is, will create confusion (Antonsen et al., 2017).

3 METHODOLOGY

3.1 *Sample*

A survey was conducted amongst the officers and more specifically the top management of the Department of Labour Inspection. A questionnaire was sent to the Director of the Department of

Labour Inspection who forwarded it to the 5 Heads of the headquarters' sectors dealing with health and safety issues as well as to the Heads of the 5 District Offices (Nicosia, Limassol, Larnaca, Paphos and Famagusta). The District Offices of Larnaca and Famagusta have the same Head.

A semi constructed interview process was selected. Participants were informed about the purpose, aims and methods of the study and assured that participation in the study was voluntary. Additionally, the anonymity of the participants will be safeguarded during and after the study, and data security will be guaranteed. They were also given the opportunity to contact the researcher in case they needed more information on the study.

In total 9 questionnaires were sent and 7 of them were answered. Two of the questionnaires were answered in great depth. The response percentage was 77.8% and can be considered to be representative.

The questionnaires were answered in three ways:

- In written and sent by email
- Orally through phone
- Face to face

3.2 *Questionnaire*

The questionnaire included 14 open questions focusing amongst other on the time needed for a non-existing legislation to be prepared and voted by the House of Parliament, the time needed for amending an existing legislation, the experience and knowledge needed by Inspectors and the difficulties in law enforcement, the perception of the Inspectors on the provisions of the legislation, the easiness to comply and understand the provisions of the legislation by both Inspectors and duty holders, the compliance of the duty holders with the provision on the adoption of new technologies and whether this provision is regularly checked by Inspectors, the role of social partners in law making and law awareness raising, as well as whether law enforcement is improving safety culture in the organization. There were also questions on how the effectiveness of legislation can be improved to reduce occupational accidents and diseases as well as dangerous occurrences.

Before giving out the questionnaire to the top management of the Department of Labour Inspection, a pilot study was conducted to verify its clarity and comprehensibility as well as if the questions were not general but strict to the point. In order to accomplish that, the questionnaires were given to Labour Inspection Officers of the Department of Labour Inspection who were familiar with the procedures of law making as well as law enforcement.

The questionnaire aimed in collecting information from the top management of the Department of Labour Inspection, on the following topics:

- Time needed for making new OSH legislation.
- Time needed for the amendment of existing OSH legislation.
- If technical updated knowledge and experience are important for law makers (DLI Officers) and why.
- Difficulties faced by Inspectors during law enforcement.
- If simpler OSH legislation implies easier enforcement.
- If there is a diversion in the way, the Inspectors interpret OSH legislation.
- Ways to achieve consistency on the way Inspectors interpretate legislation.
- If OSH legislation is easy and focused enough to be understood by:
  - Inspectors.
  - Duty holders and Stakeholders.
- Ways to improve the effectiveness of OSH legislation.
- If it is easy for the employers to understand and comply with the provision of OSH legislation on the adoption of new technologies.
- If Inspectors check on the employers' compliance with the provision of OSH legislation on the adoption of new technologies.
- The role of Social Partners in OSH legislation making.
- The role of Social Partners in OSH legislation awareness raising.
- If the enforcement of OSH legislation improves the safety culture within an organization.

4 RESULTS

4.1 *Time needed for making new OSH legislation*

The majority of the respondents answered that the maximum time needed for making new OSH legislation is 2 years. Two of the respondents specified that Cypriot Legislative Documents need more time than European and International Legislative Documents and therefore answered that 2–3 years are needed for Cypriot Legislative Documents and 18 months to 2 years for European and International Legislative Documents. One respondent had no experience and therefore did not answer. 57.1% of the top managers said that the time needed is 2 years.

4.2 *Time needed for the amendment of existing OSH legislation*

Two respondents answered that the time needed for an amendement of OSH legislation can take from 1–2 years, one respondent stated 6 months to 1 year, one respondent 1 year to 18 months, one respondent 2 years, one respondent 3 years and one respondent had no experience and therefore did not answer.

4.3 *If technical updated knowledge and experience are important for law makers (DLI Officers) and why*

Six out of the seven respondents (85.7%) agreed that technical updated knowledge and experience are important for law makers with the justification that the provisions of the legislation must be feasible to comply with and reflect reality. Lack of technical knowledge and experience can lead to the formation of legislation that could not be implemented. The respondent who answered negatively mentioned that the role of law makers is limited to legal issues.

4.4 *Difficulties faced by Inspectors during law enforcement*

All respondents agreed that there is lack of specialized training for Inspectors, the Inspectors' salaries are insufficient and they do not have the necessary evidence to convince duty holders of the benefit to comply with OSH legislation, especially the owners of small family run enterprises. In most of the times there is a negative reaction from duty holders and in some cases the Inspectors are called to face violent attitudes and threads. Due to Cyprus' small size there is "societal informality" and therefore there are many instances where peer pressure not to proceed with a "punishment" is evident. Most of the duty holders do not cultivate positive safety culture within their organization, are not aware of the provisions of OSH legislation and are against change.

4.5 *If simpler OSH legislation implies easier enforcement*

Six out of the seven respondents (85.7%) agreed that simpler legislation would help the enforcement. One of the respondents mentioned that simpler legislation combined with administrative fines would significantly reinforce the enforcement. The respondent who answered negatively mentioned that it is not an issue of understanding but an issue of mentality.

4.6 *If there is a diversion in the way, the Inspectors interpret OSH legislation*

Five out of the seven respondents (71.4%) stated that there is a diversion in the way the Inspectors interpret OSH legislation. One of them mentioned that the diversion is due to the fact that each Inspector has a personal approach and a specific technical background. Two of them answered no (28.6%) and one of them justified his answer by referring to the internal procedures and tools e.g. manuals, training and meetings, that ensure consistency of the Inspectors' perception.

4.7 *Ways to achieve consistency on the way Inspectors interpret legislation*

All of the respondents agreed that continuous training is one of the best ways to achieve consistency on the way Inspectors interpret OSH legislation additionally all of them mentioned internal guidance and joint inspections with their supervisor. Three of them also mentioned regular internal meetings and discussions on issues that is known that there are perceived differently.

4.8 *If OSH legislation is easy and focused enough to be understood by*

4.8.1 *Inspectors*

Six out of the seven respondents (85.7%) agreed that OSH legislation is easy and focused enough to be understood by the Inspectors. One of them disagreed and mentioned that OSH legislation could be simpler. Additionally, there are legislative documents that could only be understood by specialized Inspectors.

4.8.2 *Duty holders and stakeholders*

Six out of the seven respondents (85.7%) agreed that OSH legislation is less understandable by duty holders compared to Inspectors, since is more complicated due to legal and technical terms. One respondent answered that duty holders do not understand the OSH legislation and that should become simpler.

4.9 *Ways to improve the effectiveness of OSH legislation*

Two of the respondents mentioned that the OSH legislation needs simplification. Two of them stated that the application of the OSH legislation should be uniform and where there is a breach of the law then measures should be taken by the Inspectors. Moreover, two respondents agreed that there is a need to be able to inform the employers of the cost of an occupational accident or disease as well as of the benefit of compliance with OSH legislation. It was also mentioned by the respondents that more Inspectors are needed and should not be focused only on the number of inspections but on the quality of the inspection as well, the stakeholders should become more involved, economic and other incentives are essential, more resources are needed to enlighten the duty holders on the provisions of OSH legislation and finally, the timeframe for a court case to be completed should not be 5 to 8 years but much more less.

4.10 *If it is easy for the employers to understand and comply with the provision of OSH legislation on the adoption of new technologies*

Four out of the seven respondents (57.1%) answered yes, two of them (28.6%) answered yes but only in the case of large enterprises and one of them (14.3%) answered no due to the fact that the employers do not like change.

4.11 *If Inspectors check on the employers' compliance with the provision of OSH legislation on the adoption of new technologies*

Two of the respondents answered yes (28.6%), another two answered no (28.6%), one (14.2%) said that not always the Inspectors check the compliance of the employer with the provision of OSH legislation on the adoption of new technology and two of them (28.6%) stated that the Inspectors check this provision only for products and substances.

4.12 *The role of social partners in OSH legislation making*

All of the respondents agreed that the role of Social Partners in the formation of OSH legislation is very important. They express their opinion and have the means to contact the duty holders and direct them towards the correct implementation of OSH legislation.

4.13 *The role of social partners in OSH legislation awareness raising*

All of the respondents agreed that the role of Social Partners in OSH legislations awareness raising is crucial and supportive. They convey the message of the benefits of implementing OSH legislation through the organization of events like trainings, workshops and meetings and this effort is enhanced by the fact that they are in direct contact with their members.

4.14 *If the enforcement of OSH legislation improves the safety culture within an organization*

Six out of the seven respondents (85.7%) agreed that the enforcement of OSH legislation improves safety culture within an organization. Two of the respondents clarified that the enforcement on its own does not improve safety culture but should be combined with other actions e.g. personnel training. OSH culture is needed in order to protect workforce and public mainly in cases where there is not a strict and concrete legal obligation. One respondent (14.3%) disagreed with the statement that the enforcement of OSH legislation improves safety culture.

5 DISCUSSION

The main purpose of this survey was to record the Inspectors point of view on the effectiveness of OSH legislation as it is today and how OSH legislation can change and therefore become more effective in the future. Additionally, this survey aimed to identify the actual role of the different Stakeholders in the formation and dissemination of OSH legislation.

The results indicate that the formation of OSH legislation can take from 18 months to 3 years whereas the amendment of OSH legislation can take from 1 year up to 3 years. It is clarified that when it comes to Cyprus Legislative Documents the time needed is more than European or International Legislative Documents.

Law makers e.g. Inspectors of the Department of Labour Inspection is important to have up to date technical knowledge and experience so as to be able to introduce in OSH legislation, provisions that would reflect reality and be able to implement in a cost effective way.

The Inspectors are during the inspections are facing the reaction and unwillingness of duty holders to comply with OSH legislation. In some cases, the reaction is violent and threatening.

The economy of Cyprus is dominated by small enterprises. Almost all enterprises (99.9%) employ less than 250 persons whereas the overwhelming majority (95%) employ less than 10 persons (Boustras et al., 2015). The number of small family run businesses should not be ignored since most of the owners are not able to understand the importance of identifying the risks and taking measures for OSH. On the other hand, the Inspectors find it difficult to track them and due to lack of specialized training to convince them that the benefit from taking measures and avoiding occupational accidents, diseases and dangerous occurrences is greater than the cost of paying for the measures.

The number of legislative documents is huge for the Inspectors to be able to efficiently enforce it and therefore the simplification of legislation in accordance with the introduction of administrative fines could enhance the efficacy of the enforcement. The simplification of OSH legislation as well as dedication of resources for enlightening could facilitate the compliance of duty holders.

The existing diversion on how the Inspectors comprehend the provisions of the OSH legislation and how they enforce it could be enriched by more frequent and specialized training, direct supervision and guidance, as well as joint inspections.

The provision on the adoption of new technologies is incorporated in OSH legislation. The duty holders of small enterprises due to lack of resources find it difficult to comply with whereas the Inspectors check the compliance with this provision only for products and substances due to lack of specialized knowledge and lack of time.

The role of Social Partners and other stakeholders is crucial in the formation and dissemination of OSH legislation. However, this role can be enhanced by more effective intervention during law making instead of keeping a passive position and reacting only in cases were cost is involved. Additionally, except from the organization of events the stakeholders could also facilitate the timeframe of law making.

Although safety culture is intangible aspect and could cause confusion by becoming a regulatory concept, however this is not the only case, since there are many other intangible requirements in the existing regulations. This ambiguity can become a productive function since it extends the discourses of the industry and sends the tangled companies searching for safety beyond the usual destinations. Changes in the regulatory framework can introduce changes to culture and apart from regulations influence could also arise from trade unions, academia, consultants, media exposure, market trends and catastrophic incidents. The absence of the safety culture concept from the regulations is a void that when is filled will enhance the safety management at workplace. It can add value in regulation, direct both companies and consulting companies as well as the internal practice of the regulator. Furthermore, the regulator's role can change and become more proactive and informative instead of being controlling. In this way the regulator could enhance dialogue and promote continuous improvement (Antonsen et al., 2017).

6 LIMITATIONS OF STUDY

This research is limited to data collected only from the top management of the Department of Labour Inspection in Cyprus and therefore involved a small sample of seven participants. The research would benefit from a larger sample size which could also include all the Inspectors of the Department of Labour Inspection in Cyprus and especially those placed at the district offices of the Department, dealing with every day inspections and OSH legislation enforcement. The research team plans to expand to this stage in the foreseeable future.

7 CONCLUSION

This paper reveals that OSH legislation could and should change and become simpler and more comprehensive. This will support the effort of the Inspectors for uniform enforcement of OSH legislation and also will aid the duty holders to comply with it. All the stakeholders have an important role to play in the effort of changing OSH legislation. Everyone's specialized knowledge and experience could aid the formation of OSH legislation that would be broadly accepted and its implementation would be easy and cost effective.

The scope should not be the strict enforcement of the OSH legislation and the punishment of duty holders for non-compliance, but the use of the OSH legislation as a guide for the development and implementation of an occupational safety and health management system (OHSMS) that will be able to be applied by enterprises indifferent of size and especially small enterprises. The development of the OHSMS should involve all the members of the organization from top management to shop-floor workers who through safety commitment and training will create positive safety culture within the organization, enhance safety performance and thus eliminate the occupational accidents, diseases and dangerous occurrences.

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Fire safety regulation in practice: Challenges and achievements

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ABSTRACT: Many Portuguese metal working industries existed long before the publication of the current fire safety regulation. The adaptation to new regulations is rarely easy for existing industries and its assets, particularly when it comes to fire safety. How can companies protect their old buildings? How should they manage their existing resources and safety equipment? How must they invest? How should they invest? And most importantly, is it enough to protect all the workers? It was used a case study approach to the practical application of the Portuguese Fire Safety Regulation to an industrial company from the metal working sector. The analyzed facilities are 50 years old, implanted in a 33.000 m^2 ground with 19.000 m^2 of sheltered area, encompassing 145 workers. The fire risk assessment, the investments made and the prevention and protection methods created and applied allowed the company to obtain a positive statement from the responsible authority and to enhance the levels of prevention and workers' protection concerning fire safety. The positive statement from the responsible authority proved that it is possible to protect an existing building (50 years old) and its occupants from a fire scenario, even though it wasn't designed to respond to the current legal requirements. Even in older buildings, it's possible through good professional practice to improve fire prevention and enhance fire safety levels for workers and facilities.

1 INTRODUCTION

1.1 *Portuguese fire safety regulation*

Until 2008 the Portuguese fire safety legislation was very scattered and most of all extremely undemanding. In December 2008, the legal framework for fire safety came to force, applying to all types of buildings and outdoor enclosures such as schools, hospitals, industries, stadiums, museums, among others (Decree-Law Nr. 220/2008 of 12th November). It excludes rare cases, for example prisons, pyrotechnic industry and fuel filling stations. Depending on the use given to the building, it is classified in one of twelve types of building. On the other hand, depending on the fire risk assessment, it is classified in one of four risk categories: the first one includes the least dangerous buildings/outdoor enclosures (low risk), the second one moderate risk, the third high risk buildings and the forth the ones with higher risk of fire (very high risk).

One of the most important facts is that it is applicable to new building but also to all the existing ones.

This regulation demands many conditions concerning:

- Common external conditions (access roads and access to building façades; limitations on fire propagation from the outside, considering wall and roofing materials; water availability);
- General conditions for fire performance, isolation and protection (fire resistance of structural and built-in elements; reaction to fire; fire compartmentation; isolation and protection of escape routes, pipes, ducts and interior spans);
- General evacuation conditions (configuration of compartments to ensure evacuation conditions, characteristics of vertical and horizontal escape routes, areas of refuge);
- Common conditions of technical installations (specific requirements for electric power installations, heating installations, food confection compartments, elevators);
- General conditions of safety equipment and systems (requirements of certain fire safety equipment and systems considering the level of fire risk of the building: safety signs; emergency lighting; detection, alarm and alert systems; smoke control; means of intervention; fire suppression systems; contaminated water drainage);
- Self-protection conditions (safety log sheets; prevention plan/procedures; emergency plan/procedures; fire safety training; exercises and drills).

After ensuring that all these requests are met, the person responsible for the building must deliver the corresponding documentation to the competent authority (National Civil Protection Authority) and wait for a statement. Old buildings do not have to meet all the listed requirements and can adopt compensatory measures to avoid major investments as long as they assure the building is sufficiently protected against fire. These measures must be approved by the competent authority that analyzes all processes and gives its opinion, favorable or unfavorable.

Subsequently, once the competent authority has pronounced, buildings are subject to regular inspections, whose periodicity varies with the category of risk of the building.

2 METHOD

Meeting all the requirements imposed by the fire safety current regulation is very difficult for existing buildings. Proving it is a case study involving an industrial company from the metal working sector: a facility with 50 years of age, implanted in a 33.000 m^2 ground with 19.000 m^2 of sheltered area, totalizing 145 workers.

2.1 *Data collection*

To collect data the first step was to visit the facility for the recognition of the activities and spaces of the installation, as well as equipment and products used and stored.

This building integrates an administrative area, production area (with a welding and deburring sector, painting sector with a natural gas stove, electrification, among others), chemical storage area (with flammable paint), cafeteria that involves meals confectionery and paper files compartments.

The company's facilities were built in the 60's, so its constructive characteristics are conditioned to the requirements of that date. Thus, the characteristics of fire-compartmentation, the conditions of isolation and protection of the areas of greatest risk and of the escape routes are not fully known.

Initial data collection also involved recognizing the existing fire safety equipment and systems. The company had already some fire extinguishers, fire blankets on the kitchen and laboratory, fire protection network with water hoses, hydrants, safety signs, automatic fire detection system (only in the administrative area) and automatic fire extinguishing system (only in the server and UPS - uninterruptible power supply - room) - inergen fire suppression system.

A careful analysis of external conditions (surroundings) was also very important to this study. The surroundings of the facilities consist of a small industrial zone to the Southwest, housing areas to the East and West and National Ecological Reserve to the North and South. Local firefighters are 4.2 km away (approximately 11 minutes) and the police 0.75 km (approximately 2 minutes).

On the first visit to the company it was possible to acknowledge the productive process and identify infrastructures and technical installations. The company has medium voltage electricity supply, public water supply (for human consumption), water pumping system (for production areas and toilets), public sanitation network (domestic and industrial effluents), natural gas network, compressed air network and telephone network (internal fixed and portable phones and mobile phones). Technical installations cover two compressors (with 67 kW each) and a compressed air reservoir, a transformation station with a 1430 kVA transformer and a main low voltage panel, partial electrical switchboards, one computer server and UPS (uninterruptible power supply) room and one kitchen with a gas oven.

In respect of occupants the company as 145 employees that work 5 days a week: one shift from 6:00 am to 2:30 pm and 2:30 pm until 11:00 pm. The administrative workers work from 8:00 am to 5:00 pm.

2.2 *Fire risk assessment*

After the installation was acknowledged the next step was to understand its level of fire risk. To do so it was necessary to calculate the modified fire load density of all compartments and external areas, based on the technical criteria defined in specific Portuguese regulation (Technical Regulation Nr. 2074/2009, of 15th January). The principle of this calculation is to know the activities and the materials present in every compartment and estimate the fire load, applying one of two methods: deterministic and probabilistic. The first method is based on prior knowledge of the quantity and quality of existing materials in the area, while the probabilistic method is grounded on statistical results that consider the type of activity/storage in the compartment.

The fire load of every compartment on this case study was achieved using the probabilistic method. The global result was a fire load of 1901,56 MJ/m^2 in the building and 4984,33 MJ/m^2 outdoors. Per Portuguese legislation this result indicates that the company is arises to a 2nd risk category, corresponding to a moderated risk facility.

If it was a new building built from scratch, the current regulation would imply the following:

- Common external conditions: having neighboring buildings less than 8 meters away, exterior walls would have to correspond to at least a fire resistance class EI/REI60 and spans enclosed by fixed elements E30; coatings and exterior transparent elements on facades would have to comply to C-s2 d0 class (Euroclass classification) and window openings or blinds to D-s3 d0; the building would have to be surrounded by hydrants provided by public water network less than 30 meters away from the exit.

- General conditions of fire performance, isolation and protection: high risk compartments should be fireproof (kitchen, server and UPS room, production areas, paper files compartments, chemical warehouse); structural elements of fire compartments should have resistance of at least R/REI90 class and doors E45C; vertical escape routes have to be protected (not less than R/REI90 and doors E30C); conduits must be isolated on all high risk compartments; coatings on horizontal escape routes must comply to a minimum fire reaction (walls and ceilings C-s3 d1 and floors DFL-s3); coatings on vertical escape routes must comply to a minimum fire reaction (walls and ceilings A2-s1 d0 and floors CFL-s1); coatings on high risk compartments must comply to a minimum fire reaction (walls and ceilings A1 and floors A1FL); coatings on crucial areas, such as neural control and communication centers, must comply to a minimum fire reaction (A1 walls and ceilings and CFL-s2 floors).
- General conditions of evacuation: the maximum distance to go through in an escape route should be 60 meters until you reach the outside; compartments under 50 people should have at least one emergency exit and compartments with an occupancy factor of 50 to 500 people must have at least two (cafeteria and production areas); emergency exits and escape routes should have 0,90 meters of width in compartments up to 50 people and 1,80 meters in the cafeteria and production areas (occupancy factor of about 150 people); the width of the existing vertical evacuation rout should be 0,90 meters minimum (about 60 people on the first floor).
- Common conditions of the technical installations: the facility would have to have an emergency power supply (emergency generator or accumulator batteries) connected to fire safety equipment, with a minimum autonomy of 90 minutes; the circuits of the safety installations must be composed or protected by elements that ensure their integrity in the event of a fire during the minimum time established in the regulation; the kitchen should meet specific installation, ventilation and smoke extraction requirements and include emergency shutdown and command devices.
- General conditions of safety equipment and systems: if new the building should have: safety signs; emergency lighting with a minimum autonomy of 15 minutes; detection, alarm and functional alert system, covering the whole installation and during the minimum period of 12 hours; smoke control system in productive areas (active or passive) and in the kitchen (mandatory active); intervention equipment (fire extinguishers, fire blankets, fire hoses); fire extinguishing system in the painting area, properly dimensioned; firefighting wastewater drainage in all areas with products that can damage health or the environment; gas detection system in the kitchen; obligation to have a security station established at the reception desk, fire prove compartment, where all control centers of the fire safety systems are centralized.
- General self-protection conditions (documentation): safety log sheets; prevention plan; emergency procedures; fire safety training; exercises and drills every two years; safety instructions (general, particular and special).

The existing building does not meet half of the mandatory requirements. It has hydrants that distance less than 30 meters from its main exit, the required number of exits in all compartments except the cafeteria (it has only one exit and should have two) and the evacuation routes have 0,90 meters width in compartments with an occupancy factor of less than 50 people and in the stairs (vertical escape route). Regarding fire safety equipment, as listed before, not all mandatory equipment is available at the facility.

2.3 *Elaboration of fire safety documentation*

Current regulation in Portugal requires the preparation of documentation aimed at the protection of people, goods and the environment, minimizing human and material damages that may occur during the course of the company activity, by establishing a set of self-protection measures, conducive to a coordinated and organized response to emergency scenarios.

As said, the mandatory documentation varies according to the risk category of the building. In this particular case, safety log sheets were created to record relevant occurrences and keep track of fire safety related facts. These sheets include, for example, anomaly and maintenance reports in technical installations and safety equipment, training records, drill reports, checklists of routines to attest safety conditions of equipment and of high risk areas.

The documentation created also includes a prevention plan that contains the safety organization chart and attributions, as well as procedures for acting in a normal situation in order to avoid emergency situations, creating safety routines. Aware that no matter how much you bet on prevention it is possible to have a fire occurrence, emergency response procedures have been developed and compiled as well as safety instructions. These instructions include general instructions for all occupants, particular instruction for all high risk compartments and equipment and special instructions specific to members of the safety organization (safety teams).

The self-protection measures also include fire safety training plans. The participation in training and awareness-raising activities allows all workers to know the emergency risks of each space in the company's premises, thus allowing a more conscious attitude on the part of each. Likewise, it allows everyone to know and be perceptive to the procedures to be adopted, whether for prevention or for action in case of emergency. Lastly, exercises and drills are mandatory for building of the 2nd risk category at least every two years.

As mentioned, existing buildings that do not meet legal requirements can adopt compensatory measures as long as the competent authority consents them. This company adopted the following measures:

- Fifty-four people were assigned to the safety organization, including a safety responsible, safety delegate, members of a fire fighting team, evacuation team, support team and first aid team. Regulation only requires three people for 2nd risk category buildings;
- The company reinforced safety equipment beyond the quantity legally required, adding a considerable number of fire extinguishers and fire hoses;
- The detection, alarm and functional alert system (initially only present in the administrative area) was extended to productive areas, covering all the facility;
- A radio communication system was implemented, so elements of the security team could communicate without any interference;
- The reception, defined as safety station, now has all control systems (including the fire detection panel and power supply cut), a copy of all keys and a copy of fire safety documentation, including plants of the installation with representation of safety equipment;
- Although drills are mandatory every two years for building of the 2nd risk category, the company decided to practice drills once a year. Besides these drills, the company is now betting on TTX (Tabletop exercises) and CPX (Command Post Exercise) exercises. A TTX is an exercise that intends to generate discussion and problem solving by suggesting a hypothetical emergency. The CPX are also carried out in an operating room setting and aim to test the responsiveness and mobilization of resources of the various elements of the safety organization involved in emergency operations, introducing stressful situations.

2.4 *Required investments*

In order to respond to current regulation and ensure a sufficient level of fire safety of its construction, the company with a 50-year-old building had to make some investments. The first one was related to the installation of the detection, alarm and functional alert system in all productive areas and the reinforcement of fire safety equipment (acquisition of fire extinguishers and fire hoses). This was the most substantial investment, rising up to €35.000.

The development of all fire safety documentation (self-protection conditions), afterwards submitted to the appreciation of the competent authority, was also part of the budget. In Portugal, only engineers or architects recognized by the competent authority can prepare this type of documentation for 2nd, 3rd and 4th risk categories, as it implies a term of responsibility of the author. The total cost of this measure was around €2.200. Submitting the documentation to the appreciation of the competent authority represented a cost of €960.

A lot of the investment was related to training and drills. It was necessary to invest in firefighting, evacuation and first-aid training as well as specific training actions to all members of the safety organization about the procedures of the company. The company also invested on awareness training actions for all employees and service providers who work in the facility more than 30 days a year (1 hour training sessions). The training budget for training reached €3.500.

The company also prepared and executed a fire drill with the collaboration of the local fire station, that will be repeated every year, well as CPX e TTX exercises. Each one of this exercises can easily represent an investment of about €1000, depending on time and resources involved.

These investments can be considered negligible when compared to costs associated with fines imposed by the competent authority and, even more serious, costs associated with human, material and/or environmental losses in a fire scenario.

2.5 *Implementation of emergency and prevention plans*

In Portugal any favorable statement emitted by the National Civil Protection Authority after analyzing any fire related documentation reinforces that the opinion is favorable but subject to the actual implementation of all that is settled in the documents.

Therefore, the company implemented prevention and protection procedures by providing specific training to members of the safety organization, fire safety awareness sessions to all workers and service providers who work in the company more than 30 days a year, as well as by testing and improving these procedures through drills and exercises. The company also considered that visual management was a virtuous tool, so all fire safety instructions were fixed on different places, as well as the safety organization chart and emergency contacts.

Besides, maintenance and routines of inspection to safety equipment and high risk areas were implemented and reinforced, taking into account the Standard NFPA 25 (Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems). Proving these routines are safety log sheets, that are filled in every time there is a verification action. These records must be preserve for at least 10 years.

This documentation should be improved constantly, based on the results of all exercises and drills, experience gained, collecting opinions, possible changes on the process or products or other probable facts that can eventually contribute to the continuous improvement of fire safety conditions.

2.6 *Responsible authority technical review*

After analyzing the fire safety documentation delivered by the company, that included safety log sheets, prevention plan, emergency procedures, training and drills and also all compensatory measures proposed, the competent authority emitted a favorable statement, subject to the actual implementation of the facts that is settled in the documents.

With this positive response, the company should continue to implement and improve its fire safety approach and practice.

In the next 5 years, the company must request a regular inspection by this authority, in which qualified technicians will check the conditions of fire safety and confirm if the company complies with everything it has established. As it is a 2nd risk category building, the company will be inspected every 5 years.

3 RESULTS

This industrial company from the metal working sector, with a 50-year-old building, obtained a positive statement from the competent authority. This was the result of the installation of sufficient equipment and systems aiming the protection of the installations, the definition and implementation of prevention and protection procedures and the establishment of compensatory requirements to make up for the inherent constrains associated with a building that old.

With some investments at a material level and with the fortification of staff skills, the company assumed a preventive and protection approach that they believe, as well as the competent authority, will allow it to assure a high level of protection of its employees, infrastructures and the environment.

4 CONCLUSIONS

The results of this case study, mostly the favorable statement from the responsible authority, show that even a 50-year-old building can guarantee fire protection, through some investments and mostly through a high level of commitment to fire safety aspects.

When establishing fire safety conditions on building constructed until 2008 (before Portuguese fire safety regulation), it is crucial to invest in training, maintenance, inspection routines, fire safety equipment and exercises such as drills. It is also very important to keep in mind that even old building evolve on a daily basis, mainly industrial ones, and fire safety conditions and procedures must keep up with this evolution. The documentation related to fire safety cannot be static and the investment on personal skills has to be recycled from time to time.

Even though fire safety requirements were not so stringent 50 years ago, particularly regarding the construction, it is possible to protect a facility, its occupants and the environment against a fire occurrence.

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Responsive regulation: Influencing WHS improvement in a high-risk industry

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ABSTRACT: Australian WHS regulators broadly take a responsive regulatory approach, utilizing a pyramid of enforcement which provides for sanctions, directing compliance and encouraging and assisting compliance. Responsive regulation is now framed in terms of restorative justice, which draws on the values, motivations, abilities and resources of the regulatee to bring about the change. An extension to this, the pyramid of supports, provides that maintaining compliance or encouraging higher performance requires a focus on what an organisation is doing well and provision of praise and recognition. The Queensland WHS regulator developed an innovative approach utilizing both pyramids and an understanding of industry risks and dynamics to address the pervasive issue of falls from trucks in the road freight industry. By working with the industry, specific issues were identified and practical tools were developed. Outcomes achieved include improved industry attitudes towards regulation and 39% decrease in workdays lost due to injuries from falls.

1 INTRODUCTION

1.1 *Regulating work health and safety*

Implementing effective strategies for work health and safety (WHS) regulation in a rapidly changing world of work is an ongoing challenge for regulators in Australia and internationally. Ensuring that regulatory practice is evidence-based, and aligned to legislative requirements, is essential to ensure that workers and others have the highest levels of protection for their health and safety.

In the past, focus on managing obvious hazards and risks, in relatively simple work environments, was successful in achieving substantial reductions in traumatic injuries and fatalities. As work and work environments became more complex, this focus has proven to be less effective for managing all of the risks and the types of harm that workers and others are now exposed to.

1.2 *Work-related injuries from falls from trucks*

The incidence of work-related injury and disease in Australia is significant with over half a million workers experiencing a work-related injury or illness in the 2013–14 financial year (Australian Bureau of Statistics 2014). Safe Work Australia (2015) report that the incidence rate of serious injuries and disease, as recorded by workers' compensation claims, has been progressively falling since 2009, although they acknowledge limitations in the data.

Road freight transport consistently has the highest, or near highest, rate of serious workers' compensation claims for any industry subsector. This industry subsector is the largest contributor to transport, postal and warehousing having the second highest fatality rate (10.6) per 10,000 workers (in the period 2003–2015). This was only exceeded by agriculture, forestry and fishing at 17.0. By comparison, construction had a fatality rate of 3.8 (Safe Work Australia 2015). Due to the highly mobile nature of road freight transport, with work being conducted at a large number of geographically diverse worksites and across the entire road network, effective WHS regulation is more difficult than for fixed workplaces. This is further complicated as the industry is wary of regulatory interference and focusses its compliance efforts on road safety rather than occupational health and safety (Edwards 2014; Thorning et al. 2011).

Safe Work Australia (2013) report that between 2009 and 2011, there were 3100 serious injury claims from falls from trucks and from 2008–11 there were 12 fatalities. Approximately 50% of the workers' compensation claims for falls in the transport industry were for truck drivers and these had an average time off work of six weeks.

Table 1. Workdays lost, most common mechanism by agency of injury—trucks, semi-trailers, lorries, transport and storage, Qld, 2007–08 (number) (adapted from Thorning et al. 2012).

Mechanism of Injury	Work days lost
Muscular Stress: Lift, carry, Put Down	320
Muscular Stress: Handling objects	4817
Falls from a height	11168
Falls on the same level	1363
Vehicle accident	7931
Being hit by moving object	283
Muscular Stress: No objects handled	–
Total	25882

Analysis of Queensland workers' compensation statistics identified that falls from height is the single most serious risk when working around trucks, semi-trailers and lorries (see Table 1) (Thorning et al. 2012).

Further to this, content analysis of claims data showed that falling off a vehicle and entering or exiting the vehicle accounted for 90% of claims (Thorning et al. 2012).

1.3 *Regulatory approaches*

Workplace Health and Safety Queensland (WHSQ), Office of Industrial Relations is the agency responsible for regulation of WHS in Queensland. WHSQ takes a regulatory approach which is designed to ensure two main aims: that obvious risks to the health and safety of workers and others are being managed and that any breaches with legislative requirements are quickly addressed; and, that the businesses and other organisations are fulfilling their duties to ensure WHS by implementing systematic WHS management.

WHSQ broadly follows the approach espoused by Australian WHS regulators as outlined in the National Compliance and Enforcement Policy (NCEP) (Safe Work Australia 2011). This contains a version of a responsive enforcement pyramid based on Ayres & Braithwaite (1992) which advocates that most activity should occur at the base of the pyramid—where information, advice and persuasion identify that harms are occurring or could occur and the business takes action to address those harms, often with little or no action by the regulator (Ivec & Braithwaite 2015).

Where the regulatee does not recognise the potential for harm or is unwilling or unable to address it, the regulator takes increasingly intrusive actions to get the regulatee to recognise and address the potential harm (Ivec & Braithwaite, 2015). This 'tit for tat' approach was central to Ayres & Braithwaite (1992) original view about responsive regulation. However, (Braithwaite 2016) now frames responsive regulation in terms of restorative justice, where considerably more effort is put into drawing on the values, motivations, abilities and resources of the regulatee to bring about the change. Both 'tit-for-tat' and restorative justice approaches require significant interaction between regulator and regulatee: recognising the deficiency; sharing the concern; and, prompting actions to address the issue (Ivec & Braithwaite 2015). This approach is also consistent with the WHS cultural change models advocated for complex organisations (Hudson 2007).

Figure 1 shows a version of the pyramid that Braithwaite (2016) uses to demonstrate how pyramids can be applied in practice. The inclusion of willingness and ability, as a pre-cursor to deciding the compliance response, appears to draw partly from the motivational postures approach by (Braithwaite 2014). This also aligns with Black & Baldwin's (2010) approach to combining risk-based regulation with responsive regulation.

Responsive regulation encompasses considerably more than the enforcement pyramid, although this is its most well-known aspect (Parker 2013). Significantly, the pyramid concept has been extended by Braithwaite (2002) with a view that maintaining compliance or encouraging higher performance requires a focus on what an organisation is doing well and provision of praise and recognition. This has led to the development of a 'pyramid of supports' which is paired with the regulatory pyramid (Figure 2) (Braithwaite et al. 2007).

The pyramid of supports can be used simultaneously with the enforcement pyramid; praising and recognising excellence for some activities while using an escalating response to address poorly performed activities (Ivec & Braithwaite 2015). While there are many examples of regulators espousing an enforcement pyramid, there are very few examples of the pyramid of supports or both pyramids (Ivec & Braithwaite 2015).

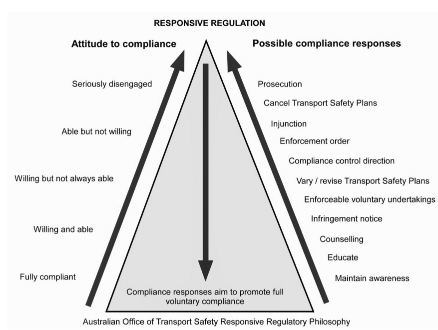

Figure 1. Responsive regulatory pyramid (Braithwaite 2016 p. 28).

Kolieb (2015) argues that the side-by-side pyramids do not represent the way in which regulation works in practice and puts forward the proposition that the pyramids should be joined at the base (with one inverted) forming a diamond. Thorning (2017) applies the approach of Kolieb (2015), and Braithwaite (2016), to construct a WHS regulatory diamond and process (Figure 3).

Responsive regulation is intended as a set of principles rather than a complete way of describing regulatory design, compliance promotion, enforcement and monitoring (Parker 2013). It is intended to be adapted to fit the operational circumstances rather than constrain the response (Parker 2013). Job et al. (2007) outline the difficulties in implementing the approach in practice. Simplistic use of responsive regulation, such as the NCEP, and, particularly, a focus on a limited understanding and utilization of the enforcement pyramid, has led to concerns that it is bolstering a deregulatory agenda which could lead to a reduction in social protection (Tombs & Whyte 2013). Conversely, more nuanced approaches should increase compliance and social protection.

Understanding how or whether responsive regulation or other inspectorial strategies work in practice is seen as important; however, few studies have been conducted (LaMontagne 2003,

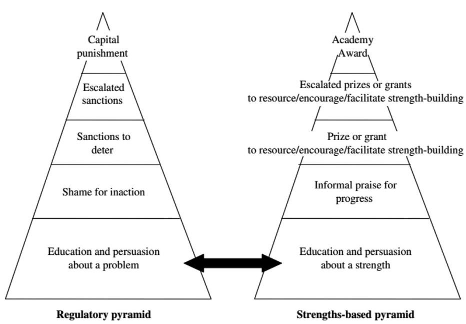

Figure 2. Pyramid of supports (Braithwaite et al. 2007 p. 319).

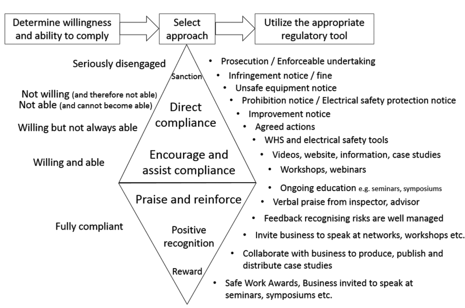

Figure 3. Regulatory diamond for WHS (Thorning 2017).

Goldenhar et al. 2001). Furthermore, Mischke et al. (2013) and Tompa et al. (2007), in their systematic reviews, conclude that the studies conducted do not provide a good evidence base. Bluff (2011), Johnstone et al. (2011) and Safe Work Australia (2013) agree, indicating that studies are limited both in terms of number and scope, particularly those relating to how regulation has been applied and whether it has been effective. The few examples of the pyramid of supports being used (Ivec & Braithwaite 2015) also indicate that additional research in this area is required.

It was using this theoretical background that a WHSQ project team (this paper's authors) applied a new regulatory approach to address the issues of injuries resulting from falls and other risks while working in, on and around trucks. Development of this approach was informed by in-depth analysis of workers' compensation statistics and detailed consultation with industry employer representatives (including the Queensland Trucking Association and a range of individual employers) and worker representatives (including the Transport Workers Union) and individual transport health and safety representatives. Following this strategic examination, the approach was formulated with specific risks being identified and programs developed to address these risks, using key aspects of the Queensland WHS legislation.

Two key elements were identified as being essential to the success of improvement strategies for the industry: firstly, worker participation in WHS decision making (essential since driver's work individually and often in isolation); and, secondly, consultation, cooperation and coordination between duty holders.

The *Preventing workers falling from trucks* intervention was designed to draw on industry knowledge, positively reinforce better practices, share collective knowledge and innovation widely in the industry, and only use enforcement measures when voluntary compliance could not be achieved.

2 THE INTERVENTION

2.1 *Introduction*

The WHSQ project team designed an intervention which utilized the regulatory diamond approach combined with an understanding of industry risks and dynamics. Key aspects were to assist businesses to fully recognize the risks to workers and others, and to use praise and recognition of excellence to motivate industry wide changes, whilst ensuring that there could be rapid escalation to directive regulatory approaches (notices) if poor performance was not quickly addressed.

2.2 *Objectives*

The objectives of the intervention were to:

- Work with industry to define and prioritise key issues
- Build industry capability to control risks
- Undertake compliance activities where risk management is inadequate
- Build industry leadership and influence positive attitudes that value health and safety
- Better understand leadership in a safety context
- Promote innovative practices and industry case studies.

The intervention delivered the following outputs:

- 30 workshops
- 13 pilot assessments
- 24 (12 paired) on-site facilitated discussions
- 12 case studies
- Industry mini-forum
- 145 assessments
- Transport industry design forum
- Short film

2.3 *Workshops*

Thirty workshops were delivered throughout Queensland over a five-month period in 2013. Twenty eight of the 30 workshops had 100% attendance with more than 400 people from the transport industry and associated supply chain attending. The materials for these two hour workshops were developed based on consultation with industry and WHSQ's understanding of some of the risks, obstacles and current solutions.

These workshops took a comprehensive approach to introduce industry to the problem, increase their awareness about the risks, improve understanding about barriers and provide practical guidance for some of the known risks. Under the guidance of the facilitators, and prompted by photographs of trucks and trailers, participants identified some of the activities, behaviors and design issues which they thought were contributing factors to how and why falls incidents were occurring. WHSQ used this information to develop the content for the next phase of the project. With reference to the regulatory diamond, this approach was essential to ensure that industry were given the opportunity to provide contextual information about compliance and the ability to describe how they believed compliance was occurring.

2.4 *Pilot assessments*

In late 2013, WHS inspectors conducted 13 planned assessments in Central Queensland prior to the full assessment rollout. The tool focused on the design of the vehicle, the equipment used, worker behaviour and activities using three separate risk categories. The results from the pilot inspections only listed two incidences of high-risk activities or behaviours. Inspectors also made numerous comments regarding the equipment available and design of vehicles, trailers and sites, but there was limited mention about the activities and behaviours of drivers.

As these observations did not support accumulated understanding of how injuries were occurring, it was speculated that inspectors were not identifying high-risk activities or behaviours because there was a low number of pilot assessments, they were limited to only one location, and it was not a representative sample. The presence of inspectors is also likely to have resulted in workers altering their behaviour and work activity.

This was an essential step in the process of determining effective ways to choose and apply regulatory tools. From these pilots, it appeared that using more directive approaches, such as notices, could shift the focus from the real underlying causes of falls to more simplistic causes and the issuing of notices which would be difficult for business owners to comply with in practice.

2.5 *Industry mini-forum*

In February 2014, WHSQ conducted a mini-forum with 29 industry representatives about falls prevention. Facilitated discussions occurred with participants and they were asked to nominate what they considered when looking at falls risks within their own business. They were also asked to provide suggestions as to how WHSQ might be able to further facilitate improvements in how the road freight industry manages the risks of falls.

Participants discussed emerging issues relating to the industry, mainly around design issues for heavy vehicles and trailers. They commented on the ability of industry to negotiate amongst themselves and manufacturers to make these safety changes. This information helped to inform the truck design meeting held in November 2014. Input from participants included:

Issues:

- Different vehicles don't have proper hand holds (three points of contact)
- Height for last step, this forces drivers to stretch to get into the vehicle
- First step to tank, cab or trailer has 'irregular' heights
- Last step always too high, and the distance between steps is uneven
- No current standard for truck cabs regarding the dimensions of drivers

– Steps are shallow on 'cab over' entry, forces drivers to get into vehicle in awkward position

Solutions:

– Three points of contact as an industry standard for design of heavy vehicles
– More hand rails on vehicle; so any driver of any height can have three points of contact
– Non-slip steps should be mandatory within the standard
– Rubber hand holds and non-slip grip tape for stairs should be colour coded, e.g. yellow LED spot lights to highlight the steps of the cab for drivers
– Intuitive design, so drivers use the steps and handles properly, designed in a way the driver will use

Participants also identified numerous issues and solutions around the risk of falls, mainly related to equipment, vehicle and trailer design. There was a special mention of the Australian Design Rules, which are the national standards for vehicle safety, but which appear to focus primarily around on-road safety. A key point was that manufacturers should consider the anthropometrics and demographics, i.e. stature, size, age and gender, of the Australian trucking industry workforce.

There were also comments about retro fitted aftermarket 'fixes' that the industry currently uses to manage safety risks to workers. It was generally felt that some designs should be included in the design standards and completed by manufacturers to avoid costly and time-consuming retrofitting.

2.6 *Workplace assessments*

Following the workshops, in late 2014 and early 2015, WHSQ conducted 145 workplace assessments. These were aimed at further assisting business operators and workers to identify equipment and activities which exacerbate the risk of falls, and to implement effective risk management. The workplace assessments were designed to gather information about current industry practice, provide information about better practice, and to allow a stronger compliance approach, with a focus from the regulatory diamond of using directive measures for those business operators who appeared unwilling or unable to comply. However, inspectors found that issuing notices during this assessment process was difficult because workers avoided high-risk activities while the inspector was on-site and there was insufficient evidence to support a reasonable belief of a breach.

Further to this, inspectors found business operators and workers were receptive to identifying the risks and implementing action to address the risks when an approach of discussion, documentation and follow-up was used. This approach is loosely termed as "agreed actions" and is used to describe the giving of advice and seeking voluntary compliance. It is considered just below notices on the regulatory pyramid, and is used as a flexible and discretionary way in which inspectors can achieve compliance. Actions range from an inspector identifying a hazard at a workplace and it being rectified immediately, to a long-term strategy of continuous improvement that is recorded in an action plan and closely monitored. If the duty holder fails to achieve the identified outcomes within the prescribed timeframes the inspector can quickly move to using a notice to ensure compliance. The decision to utilize agreed actions rather than write a notice is based on the evidentiary requirements for the notice and a risk management approach. That is, agreed actions are only appropriate for lower level risks. Higher level risk justifies an improvement or prohibition notice and the time and resources required to satisfy the evidentiary requirements.

Issues identified were around three main areas: the cab of the truck; trailers; and, ground level on-site. Seventy-one percent of issues regarded trailers.

Comments from inspectors indicated a high level of design problems associated with the height or quality of the steps and handholds to gain access to the cab to achieve safe three points of contact. Other comments indicated that there was usually no access to the trailer, forcing workers to use fuel tanks or tyres. If there was a built-in ladder or steps on the trailer, they were often too high for workers. These reflect some of the design issues discussed and documented from the preventing falls mini forum held in February 2014.

2.7 *On-site facilitated discussions*

After the outcomes of the workshops, pilot assessments and mini forum, the project team determined that an on-site facilitated discussion would be an effective way to enable businesses to manage their own falls risks. Twelve on-site discussions were conducted with businesses about their falls risks. A *Risk identification process and action plan* (RIPAP) tool was developed to support these discussions.

The main aim of this deliverable was to test a deeper engagement approach to enable businesses to identify and manage their own falls risks. Project staff achieved this by coaching businesses on how to conduct a low-level risk identification process and implement a solution using consultation, which they would then incorporate into their regular business practices.

The RIPAP tool and process broadly uses the hazard/risk identification and control, and consultation sections approach of the Australian and New Zealand Standard 4801: *Occupational health and safety management systems* standard

(Standards Australia 2001). The project team combined this with intelligence gathered on the three priority risk areas from the pilot assessments and workshops. The tool was designed using consumer behaviour theory to reduce cognitive dissonance (audience disagreement) with its messaging. The tool uses plain English to match the language to the audience's understanding of the topic, and a simple layout to improve readability.

The on-site discussions typically had between six and 12 people looking for falls risks on one of their trucks or trailers at their site. The project team mainly facilitated these with an inspector in attendance. Drivers, staff from their mechanical workshop, an Occupational Health and Safety (OHS) Officer and a manager were present at most of these visits to enable consultation to occur between a 'vertical slice' of the business.

The process usually took around one and half hours, with members of the group identifying falls risks using the tool provided. While observing the truck, the group identified where there may be a risk of falls in the three priority areas and then returned to a meeting room to discuss their inspection.

The participative group then chose one of the highest risks identified, and discussed solutions to address that one risk. They agreed upon realistic timeframes for the changes discussed and the coordinator provided the link between members of the group who are responsible to implement the changes. Project staff and inspectors followed-up with the businesses involved by asking for information on their progress. Their progress was reviewed with regards to implementing agreed solutions, usually via email with photos of the changes.

The process proved successful in providing the tools for workplaces to manage their own risks of falls. All 12 on-site discussions ran as intended, with highly desirable outcomes achieved and recorded across all of the visits.

Further follow-up occurred with each participant of the on-site discussions, to review their progress and collect information to contribute to potential case studies.

2.8 *Case studies*

The project team designed the on-site discussions to capture the outcomes in short case studies. In partnership with the businesses, the project team wrote-up and published the case studies. The case studies are aimed at showing a simple approach for businesses on how to manage their risks and to promote practical examples to industry on how to manage falls.

The case study by Australian Amalgamated Terminals (AAT) provides a good example of the approach taken.

2.9 *Australian Amalgamated Terminals (AAT) – Preventing workers falling from trucks*

The potential dangers involved with numerous different operators, freight and vehicles on one site are something Australian Amalgamated Terminals (AAT) face on a daily basis. AAT operate a multi-user terminal at the Port of Brisbane.

With a number of businesses operating various vehicles, trailers and load types within one terminal, the risk of falls from trucks was identified as a serious issue requiring attention. AAT decided to take a consultative approach to identifying and managing the risks associated with falls from trucks.

AAT participated in a WHSQ workshop on preventing workers falling from trucks and used this to start an internal safety group. This group undertook consultation, including discussion with major transport contractors within their supply chain, to identify the load types and relevant operators involved.

The coordinator of the internal safety group then formed four consultative groups, one for each of the load types that AAT receives: steel transporters; "roll-on, roll-off" heavy machinery transporters; general freight, and, cars.

Each group looked at identifying the known risks about falls specific to that load type. From this, the group began identifying and developing best practice solutions to managing the risk of falls.

As a result of this program, AAT have implemented several control measures since the consultation commenced. One of the more significant controls has been the introduction of mobile work platforms. To support this, AAT prepared instructions on their use, and conducted training for both internal staff and their supply chain. They have just completed a short safety video that includes how to use the mobile work platforms.

AAT will reflect these changes in their site policies and procedures and ensure that they are effectively communicated to existing and new operators coming on site. It is expected that the uniform policies and procedures will improve efficiencies when loading and unloading.

2.10 *Truck design forum*

WHSQ facilitated a forum about truck design and falls prevention with trucking industry leaders in November 2014. Participants discussed a wide range of issues surrounding design of vehicles, trailers and sites. Discussion focused on the existing issues and the risks associated with the features on their trucks and what changes they had to make following purchase. There was a particular focus on retrofitting safety features to their existing fleets. This included non-slip steps for climbing on and around trucks and LED lights on the doors to make it easier to see where they were stepping at night.

As an outcome of the forum, it was proposed that collaborative development of key principles to guide the procurement of equipment should occur. Attendees noted that Australia only has a small voice among the US, European and Asian original equipment manufacturer (OEM) markets and members felt that they are in a difficult position to influence manufacturing design. It was noted that Australia has a strong safety culture but weaker purchasing power, and other more influential countries (because of their purchasing size) may have a different culture for safety tolerance. It was also noted that the lag time from truck re-design to manufacturing production line changes was generally more than five years. As a first step to influencing better design, participants agreed to share images and details of any retrofitted controls they have made to their vehicles. This information could then be used in discussions with representatives of vehicle manufacturers.

2.11 *Additional activities*

To further facilitate changed approaches, WHSQ released a short film in 2015 and facilitated a well-attended webinar about falls in 2016.

3 RESULTS

Factors in risk of falls from trucks included:

- Poorly designed ladders or steps
- Climbing at height onto the trailer to secure loads
- Climbing on the top of the trailer where there are unprotected openings
- Ladders or steps unsafely located on the trailer
- Climbing at height up or between ramps or crates on the trailer to access loads
- Climbing at height onto the trailer or carrier to load or unload
- Jumping down from the trailer
- Using tyres as steps to climb onto the trailer/ walking on trailers that have become slippery with contaminants
- No 'three points of contact' to the entry of cabs
- Climbing at height to perform mechanical maintenance on the truck
- Climbing at height to clean the truck
- Walking on surfaces around load areas and ramps contaminated with water, diesel, mud or ice.
- Walking on surfaces around load areas and ramps that have ground hazards and/or signs of wear and tear
- Using unsafe access steps around load areas and ramps

Table 2. Workdays lost (where the agency of injury is Trucks, Semi-trailers and Lorries).

	2007/08	2015/16	% change
Falls from a height	11168	6761	–39%
Muscular stress, handling objects	4817	3896	–19%
Muscular stress, lift, carry, put down	320	173	–46%
Falls at the same level	1363	1372	+1%
Being hit by moving objects	283	No data	–
Vehicle accident	7931	4945	–38%

Data for the road freight transport industry sector show that there has been a general decline in the claim incidence rate (time lost claims) over the past five years. In 2015–16, road freight transport had a claim incidence rate of 33.2 claims per 1,000 employees—down from 43.1 in 2011–12.

There has been an overall reduction in the total number of accepted non-fatal claims across all industries in Queensland over the period from 2007–08 to 2015–16 in the order of 25 per cent. A reduction of approximately 27 per cent has been seen in the transport, postal and warehousing industry in Queensland over this time.

More specifically, the heavy road freight sector which is the highest risk area, and the main target of the interventions, shows a significant decline in the workdays lost for mechanisms of injury that WHSQ focused on (Table 2), including a 39% reduction for falls from a height. This clearly demonstrates the effectiveness of the intervention approach.

4 CONCLUSIONS

WHSQ has a focus on achieving its regulatory aims through a mix of direct regulatory approaches, including: improvement and prohibition notices; acting to achieve compliance voluntarily through education, advice and persuasion; and, providing praise and recognition. This increases the capability for businesses to effectively manage their own WHS risks. The *Preventing workers falling from trucks* intervention used a collaborative and facilitative approach to empower businesses in managing their own risks.

The engagement style approach allowed WHSQ to test the guidance materials and tools produced with businesses. The risk identification process and tool were well received by industry and were successful in guiding risk management solutions.

Industry perceived the facilitated falls risk identification process as 'looking through the eyes of the regulator' and expressed appreciation for the additional insight they gained about WHS management. This had a snowballing effect, with some businesses implementing additional changes and creating their own guidance materials for their workers and their supply chain. The lag indicators, such as injury rates, are now showing improvement, and other indications are that businesses are embracing the approach and actively developing and implementing effective solutions. Longer term feedback from industry indicates that the cultural change process is working and, in a recent survey, road freight industry respondents overwhelmingly expressed commitment to WHS regulation and reasonably high trust in the regulator (Braithwaite & Cleland 2017).

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Critical analysis on occupational safety and hygiene law and its implementation—a case study of Vietnam's rubber industry

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ABSTRACT: The Vietnam's Law on Occupational Safety and Health issues in 2015 and effected on 2016. This is the first time that Vietnam issued a specific Law to provide for measures guaranteeing Occupational Safety and Health (OSH), policies and compensation for victims of occupational accidents and diseases; responsibilities and rights of organisations and individuals in respect of OSH and state management for OSH. It is a perspective sign that indicates the assurance of labour safety and hygiene has been gotten indication of interest by the government. However, after this Law has been taken effect for 8 months, the benefits from applying the Law to the working conditions of workers in rubber manufacturing industry have not been significantly considered. The relevant ministry has not issued necessary legal documents under the Law for guiding the implementation of Law and regulations. Besides, the revaluation of severity factors of working conditions in order to reclassificate working conditions has not been implemented. Additionally, the workers have not received and recognized enough OSH rights during the working process and at the workplace. Therefore, this study did a critical analysis of the effects and limitations of the Vietnam's Law on Occupational Safety and Health to working conditions of workers in rubber manufacturing industry. Finally, the appropriate recommendations would be suggested to improve working conditions of workers.

Keywords: The Vietnam's Law on Occupational Safety and Health; Working Condition; Rubber Manufacturing Industry

1 INTRODUCTION

Vietnam Government considers Occupational Safety and Health (OSH) as one of main socio-economic policies, main targets for the country development. The National Law on OSH effected on 1st July 2016 including 7 Chapters and 93 Articles. However, the occupational accidents and diseases are observed being reduced pretty lightly. There are still several serious accidents leading to injuries and deaths have occurred in the enterprises. Moreover, majority of the enterprises did not report the number of accidents to the public and the government. Therefore, from 2015, Vietnam has pushes many movements and programs to enhance OSH Law and its implement throughout the country. The number of workers receiving OSH training has been also increasing annually [1]. Ultimately, the main target of OSH Law 2015 to enhance knowledge and fully comply with the regulations on OSH in order to improve the working conditions, prevent occupational accidents and diseases, protect the workers' health, contribute to the sustainable development of the country. In this year, Vietnam will ceblerate the milestone of 120 years of rubber trees have being planted in the country, and the 88th anniversary of Vietnam Rubber Day from 1929 to 2017 [2]. Therefore, the main objective of this study will review and analysis the Vietnam's Law on Occupational Safety and Health to working conditions of workers in rubber manufacturing industry, and suggest the appropriate recommendations to improve working conditions of workers.

2 LITERATURE REVIEW OF THE IMPLEMENTATION OF OCCUPATIONAL SAFETY AND HYGIENE LAW IN VIETNAM AND WORLDWIDE

2.1 *Worldwide*

It is report that every day, there are 6,300 people die as a result of occupational accidents or work-related diseases, and more than 2.3 million deaths per year. Annually, there are 317 million accidents occur on the job, which is resulting in extended absences from work [3]. While there are a sobering number of news stories that one can encounter on an almost daily basis, there are in fact legal frameworks within all Asian countries for managing Occupational Health and Safety (OHS) issues. For example, China coal-mine explosion, which resulted in 11 deaths in Guizhou province in 2014. While in Bangladesh textile workers fed up with working conditions, which causing over 200,000 workers have taken to the streets, some clashing with police, rioting and setting factories alight, to demand a higher minimum wage. The offivial statistic of the International Labour Organization also revealed that every 15 seconds, a worker dies from a work-related accident or disease, and 153 workers have a work-related accident [4].

Terminology followed when describing health and safety Laws varies among countries; belows are some commonly used terms. **Legislation** is a Law that has been promulgated by a governing body. For industry, occupational or worker health and safety legislation provides the legal boundaries. **The Laws** within which an industry or company operates. In many countries these are referred to as **Acts**, e.g., Factories Act or Health Act. After legislation is passed, regulators will be tasked with providing the details **regulations/standards** that industry needs to follow to be compliant with the Law. **Standards,** as they pertain to OHS, can have different meanings depending upon the jurisdiction. For instance, US Federal Occupational Safety and Health Act (OSHA) standards (29 CFR) are far encompassing and impose requirements that target industry. In other countries, e.g., Afghanistan, standards or regulations have not yet been developed. In many jurisdictions, **guidelines (or other similar documents)** are issued by the responsible regulatory body to clarify and provide further details related to how to implement the Laws and regulations. For the Health, Safety and Environment (HSE) professional, it is your job to fully understand which Laws, regulations, guidelines, standards and other pertinent regulatory requirements affect your business to ensure you are operating in compliance with all jurisdictional requirements.

Table 1 gives a broad summary of the state of worker health and safety (represented by worker fatality data) and Laws and regulations governing worker health and safety for each country in Asia. This is admittedly a very broad overview and in future posts discussing on OHS Laws and regulations in more detail for specific countries.

As expected, the US and UK both have well developed worker health and safety regulations, which are enforced and complied with by industry, the result is low rates of worker fatalities. The relatively wealthy countries of North-East Asia have generally less developed regulatory environments compared to the US and UK but have equally low rates of worker fatalities. Across the Middle East, regardless of the vast differences in wealth among these countries and major differences in the legal and regulatory regimes, the rates of worker fatalities are high and in a tight range from 13.3–16.8 fatalities/100,000. Rates on worker fatalities in SE Asian countries are very high, with the exception of the two wealthiest counties—Singapore and Malaysia.

Figure 1 presented the noteworthy trends and relationship between Worker Fatality rate and Gross Domestic Product (GDP) in Asian countries. There is a strong negative correlation between worker fatality rates and country wealth. The highest worker fatality rates (over 30/100,000 workers per year) are pretty much restricted to countries with GDP less than about $5,000 per year.

The four general groups are noted:

- Group 1 (red): Undeveloped/developing countries with high fatality levels and with major shortcomings in Laws and regulations and/or lack of enforcement and/or lack of compliance: Afghanistan, Bangladesh, Cambodia, Indonesia, Laos, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Thailand, and Vietnam.
- Group 2 (yellow): Undeveloped/developing countries with lower fatality levels but with shortcomings in Laws and regulations and/or poor/inconsistent enforcement and/or compliance: China, India, Iraq, Iran, Jordan, Kazakhstan, Kyrgyzstan, Lebanon, Malaysia, Maldives, Russia, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan, and Yemen.
- Group 3 (blue): Wealthy countries with high fatality levels, generally with rapidly evolving Laws and regulations but with poor/inconsistent enforcement and/or compliance: Bahrain, Brunei, Israel, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates.
- Group 4 (green): Wealthy countries with low fatality levels, comprehensive legal and regulatory framework, and strict enforcement and compliance: Hong Kong, Japan, Macau, Singapore, South Korea, and Taiwan.

Generally, the most highly developed countries typically have the most comprehensive legal requirements for worker health and safety, and these Laws have generally been in place for more than 25 years. However, in fact, there is no strong relationship between worker safety and the complexity and thoroughness of a county's Laws and regulations.

2.2 *Vietnam*

In Vietnam, the Law on OSH has been given a green light, marking a significant milestone by extending the protection and preventive efforts to the informal economy. The Law was the first one of its

Table 1. Overview of Asian countries on worker health and safety Laws and regulations [4].

Country	GDP (USD) 2014	Fatality/100,000 Workers/Year	Promulgation of OHS Law	Primary OHS Law
Western	**$ 50,116**	**3.00**	**1972**	**(median values)**
United Kingdom	$ 45,603	0.80	1974	Health and Safety at Work etc. Act 1974
United States	$ 54,630	5.20	1970	Occupational Safety and Health Act of 1970
North-East Asia	**$ 27,971**	**4.64**	**1986**	**(median values)**
China	$ 7,594	10.50	2001	Code of Occupational Disease Prevention of PRC (2001) and Production Safety Law of the PRC (2002).
Hong Kong	$ 40,170	4.95	1997	Occupational Safety Health Ordinance (1997)
Japan	$ 36,194	3.20	1972	Industrial Safety and Health Law (1972)
Macau	$ 96,44	4.64	1986	General Regulation on Occupational Safety and Hygiene in Industrial Establishments (1982)
Mongolia	$ 96,44	19.90	None	No specific OHS legislation in place; OHS primarily under Labour Law (1999)
South Korea	$ 27,971	4.23	1990	Industrial Safety and Health Act (1990)
Taiwan	$ 22,598	3.31	1974	Labour Safety and Health Act (1974)
South-East Asia	**$ 2,843**	**22.10**	**2000**	**(median values)**
Brunei	$ 40,776	10.00	2009	Workplace Safety and Health Order (2009)
Cambodia	$ 1,084	28.30	None	No specific OHS legislation in place; OHS primarily under Labour Law (1997)
Indonesia	$ 3,515	20.90	1970	Work Safety Act (1970) and The Health Act (1992)
Laos	$ 1,708	28.80	None	No specific OHS legislation in place; OHS primarily under Labour Law (1994)
Malaysia	$ 10,538	18.30	1994	Occupational Safety and Health Act (1994)
Myanmar	$ 1,198	26.00	None	No specific OHS legislation in place; OHS primarily under Factory Act (1951)
Philippines	$ 2,843	20.00	1978	The Occupational Safety and Health Standards (1978)
Singapore	$ 56,287	1.60	2006	Workplace Safety and Health Act (2006)
Thailand	$ 5,561	23.30	2011	Safety, Occupational Hygiene and Workplace Environment Act (2011).
Timor-Liste	$ 1,280	N/A	None	No specific OHS legislation in place; OHS primarily under Labour Code (2012)
Vietnam	$ 2,052	27.00	None	No specific OHS legislation in place; OHS primarily under Labour Code (2002)
South Asia	**$ 1,631**	**19.50**	**2007**	**(median values)**
Bangladesh	$ 1,097	26.40	None	No specific OHS legislation in place; OHS primarily under Factory Act (1965)
Bhutan	$ 2,379	N/A	2007	Labour and Employment Act (2007)
India	$ 1,631	11.50	None	No specific OHS legislation in place; OHS primarily under Factory Act (1948)
Maldives	$ 8,625	13.91	None	No specific OHS legislation in place; OHS primarily under Employment Act (2008)
Nepal	$ 698	29.90	None	No specific OHS legislation in place; OHS primarily under Labour Act (1992)
Pakistan	$ 1,334	20.70	None	No specific OHS legislation in place; OHS under several different pieces of legislation, e.g., Factories Act (1934)
Sri Lanka	$ 3,631	18.30	None	No specific OHS legislation in place; OHS primarily under Factories Ordinance (1942)
Central Asia	**$ 2,603**	**18.30**	**1993**	**(median values)**
Afghanistan	$ 666	19.90	None	No specific OHS legislation in place; OHS primarily under Labour Code (2007)
Kazakhstan	$ 12,276	10.70	None	No specific OHS legislation in place; OHS primarily under Labour Code (2007)

(*Continued*)

Table 1. *(Continued)*

Country	GDP (USD) 2014	Fatality/100,000 Workers/Year	Promulgation of OHS Law	Primary OHS Law
Kyrgyzstan	$ 3,169	18.60	None	No specific OHS legislation in place; OHS primarily under Labour Code (2004)
Tajikistan	$ 1,099	18.60	None	No specific OHS legislation in place; OHS primarily under Labour Code (1997)
Turkmenistan	$ 9,032	17.90	None	No specific OHS legislation in place; OHS primarily under Labour Code (2009)
Uzbekistan	$ 2,038	18.00	1993	Law on Occupational Safety and Health (1993)
Middle East	**$ 15,486**	**15.70**	**1987**	**(median values)**
Bahrain	$ 25,198	15.70	None	No specific OHS legislation in place; OHS primarily under The Labour Law for the Private Sector (1976)
Iran	$ 5,293	16.80	None	No specific OHS legislation in place; OHS primarily under the Labour Law (Labour Code) (1990)
Iraq	$ 6,433	14.20	None	No specific OHS legislation in place; OHS primarily under the Labour Law (1996)
Israel	$ 37,032	14.60	1970	Worker Safety Ordinance (1970)
Jordan	$ 5,423	15.60	None	No specific OHS legislation in place; OHS primarily under the Labour Law (1987)
Kuwait	$ 52,196	13.30	None	No specific OHS legislation in place; OHS primarily under Law Concerning Labour in the Private Sector (2010)
Lebanon	$ 10,139	15.90	2004	Decree No. 11802 on Occupational Prevention, Safety and Health (2004)
Oman	$ 20,832	18.90	None	No specific OHS legislation in place; OHS primarily under the Labour Law (1973)
Palestine	$ 1,924	N/A	None	No specific OHS legislation in place; OHS primarily under the Labour Law (2000)
Qatar	$ 93,397	15.10	None	No specific OHS legislation in place; OHS primarily under the Labour Law (2004)
Saudi Arabia	$ 25,409	15.70	1969	Royal Decree No. 21 on Safety in the Workplace (1969)
Syria	$ 4,685	17.70	2010	Legislative Decree No. 28 relating to Occupational Safety and Health (2010)
United Arab Emirates	$ 42,522	15.90	None	No specific OHS legislation in place; OHS primarily under the Federal Law on Labour (1980)
Yemen	$ 1,473	17.00	None	No specific OHS legislation in place; OHS primarily under the Labour Code (1995)

* N/A: Not available.

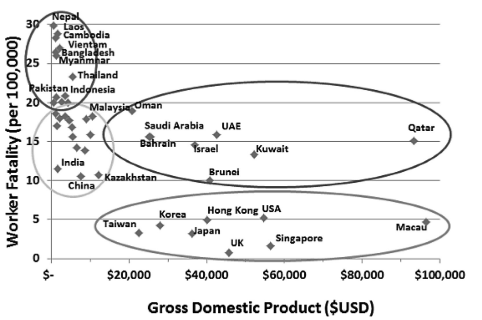

Figure 1. The trends and relationship between worker fatality rate vs GDP in Asian countries.

type, which was passed on 25th June 2016 by the National Assembly with a large majority (89%) voting in favour and took effect from 1st July 2016 [5]. The enforcement of the Law will be another challenge for the country in the coming years. However, there are many challenges in promoting the Law through awareness raising and trainings should be given a priority to ensure that employers, workers and those working outside the formal economy are aware of the new obligations. The adoption of the Law signaled Vietnam's commitment to addressing occupational safety and health and followed the ratification of the promotional framework for occupational safety and health convention, 2006. The

Law was also expected to contribute to the effective implementation of the principles enshrined in the Occupational Safety and Health Convention, 1981, which was ratified by Vietnam in 1994.

Especially, enhancing cooperation with international organisations and foreign countries in labour safety and hygiene will is priority, when Vietnam curretly has a Law on occupational safety and hygiene. In addition, every province and city should promptly accumulate experience in effectively enforce the Law on occupational safety and hygiene, build policies on the compensation fund for work-related accidents and diseases. According to the World Health Organisation (WHO) and the International Labour Organisation (ILO) estimated that economic costs of work-related injuries and illness of Vietnam are equivalent to 3–5 percent of a country's Gross Domestic Product.

Policies on operating the occupational accident insurance fund for workers are needed to promulgate in order to ensure flexibility in administrative procedures and compensation while financial supports for poor and near-poor households should depend on the country's socio-economic development and local budget in each period. Besides, all local governments should pay attention on training courses to raise public awareness of labour safety and hygiene to all enterprises.

3 ANALYSING THE INFLUENCES OF OCCUPATIONAL SAFETY AND HYGIENE LAW TO VIETNAM'S RUBBER INDUSTRY

3.1 *Specific points of the Law affecting on rubber manufacturing*

Employers are responsible for ensuring the working environment meets the required standards, improving the healthcare and working conditions of workers, and establishing practices to minimize or eliminate safety and health related hazards. Employers must ensure the safety and health of employees and the environment when building or renovating new facilities or when purchasing equipment that has strict OSH requirements [6]. The followings are some specific points of OSH Law 2015, which critically affect on rubber manufacturing workers [7].

- Enterprises with more than 1,000 workers are required to establish an OSH Council.
- The OSH Council is a coordinating and advisory unit within the enterprise. It ensures the participation and supervision of the Trade Union in OSH activities.
- A representative of the employer shall be the OSH Council Chairperson.
- A representative of the Trade Union shall be the Vice Chairperson of the OSH Council.
- A designated Labour Protection Chief Officer or an alternate individual designated with responsibility for labour protection must be a standing member and secretary of the Council. The maximum number of OHS Council members is 9.
- Inspections must be carried out at regular 6 month intervals to ensure attention to OSH issues.
- Annually, employers must develop or update the OSH plan, which must include the following:

  a. Measures on occupational safety and fire fighting
  b. Measures on occupational health and improvements on working conditions and environment
  c. Provisions on Personal Protective Equipment (PPE)
  d. Healthcare for workers to prevent work related illnesses
  e. Information and trainings on OSH

- The OSH plan must specify the costs, completion date and people in charge for each activity/measure.
- The employer must develop rules on labour safety for all types of machinery, equipment and materials and apply these in the workplace.
- When developing the OSH plan, the employer must consult the Executive Committee of the Enterprise Union (or the Executive Committee of the immediate upper-level Union in a non-unionised enterprise).

3.2 *Influences of OSH Law to working condition of Vietnam's rubber manufacturing workers*

Depending on specific points of rubber manufacturing, the Vietnam General Confederation of Labour (VGCL) and the Vietnam Rubber Industry Group (VRG). The VRG union suggested to reduce retirement age for rubber workers. Therefore, from June 2015, the Ministry of Labour, Invalids and Social Affairs proposed retirement age for 60 years old for male workers and female workers are 47 years old, which reduced 3 years old compared to the current 50 years for female case. Besides, some specific points for reducing retirement age for femail workers are (i) working time from 4–5 hours, some case working at 2–3 am; working position is not suitable to work for long-time, e.g. leaning 30–32° above the ground; working conditions and working environment such as slippery slopes, damp slopes, lack of light, respiring many CO_2 gases. Therefore, rubber workers often suffer from skin diseases, anemia, respiratory infections, skin ulcers, high rates of women with cancer diseases. Currently, although rubber manufacturing has been classified as hazardous and dangerous job in Vietnam [8].

Figure 2. Rubber tapping workers are working under hazardous conditions in Vietnam.

Figure 2 shows the working conditions of rubber tapping workers, due to the specific characteristics of the rubber industry, if the workers do not pay attention to the direct and indirect effects of the working environment, there may be adverse effects on their health. It is time for the rubber industry to pay more attention to health. Hence, the OHS Law suggested that regular physical exams annually have to be used to make accurate assessments of worker's health status for long-term health care options.

4 CONCLUSION AND RECOMMENDATION

The current status and influence analyses of OHS Law to Vietnam's rubber industry revealed that there are still a lack of specific policies and regulations under the Law to defend workers's health of rubber manufacturing. However, after two year, the Law has been taken effects and benefits to slowly improve the working conditions and labour rights of workers in rubber manufacturing industry. There are also suggestion for some detail relevant legal documents and under the Law for guiding the implementation of Law and regulations. In addition, the workers should be training and realize their real OSH rights during the working process and at the workplace. The followings are recommendations suggested to improve working conditions of rubber industry workers.

- All provisions of the Law must be fully practiced and trainned to rubber enterprises and rubber manufacturing workers.
- Regarding the compensation fund, it need to be seriously set up for the disabled employees and retirement employees of occupational accidents and occupational diseases in order to strengthen the social security system in support of labour rights.
- The rights and responsibilities of socio-political organizations, social and professional organizations in OSH work should be specific regulated, and take place in to practice at lowest local government.
- It is also necessary to provide for OSH specialized inspectorate. OSH inspectors will be assigned to prevent violations that can cause worker fatalities or conflicts between enterprise and employees.

This study is strongly concluded that since the Vietnam's OHS Law consider above recommendations into rubber industry, that could bring such benefits and efficiencied for the protection and development of Vietnam's working force and approaching to the sustainable development of Vietnam's rubber industry.

NOMENCLATURE

CFR: Code of Federal Regulations; HSE: Health, Safety and Environment; ILO: International Labour Organisation; GDP: Gross Domestic Product; OSHA: Occupational Safety and Health Act; OHS: Occupational Health and Safety; PPE: Personal Protective Equipment; USD: United States Dollar; VGCL: Vietnam General Confederation of Labour; VRG: Vietnam Rubber Industry Group; WHO: World Health Organisation.

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Managing safety-related compliance in differing market areas

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ABSTRACT: In global trade, a machine manufacturer must localize its products for different market areas and customers. It must manage a large variety of safety requirements, conformity approvals and product liability issues. The objectives of this study are to review 1) the problems experienced in managing product safety–related compliance in differing market areas and 2) the practices applied to manage compliance. The focus is on the differences in regulatory frameworks for product safety in the European Union (EU) and the United States of America (USA) markets. The study is based on a literature review and interviews with representatives of five European machine manufacturing companies and 16 external organizations that effect on managing compliance. The legal traditions in these two market areas are very different, and the participating EU companies find that the USA market requires special care.

1 INTRODUCTION

European integration has clarified the operations of machine manufacturing companies extensively within the EU. The legislation and standards for machinery are mostly harmonized among the EU member states. The main instrument for regulating safety of most machines in EU member states is the Directive 2006/42/EC on machinery (the Machinery Directive), and a CE conformity marking is applied to indicate compliance with the directive's requirements. In contrast, the USA market has more state-specific legislation and a completely different framework for safety issues.

Legislation in the EU is derived from the civil law tradition, but legislation in the USA is derived essentially from the common law tradition of England. Within the common law tradition in the USA, the legal praxis is commonly more important than actual legislation (i.e. case law). Thus, EU companies believe that they must be well prepared for the USA market. In particular, the costs of possible legal actions induce uncertainty in foreign companies. In the EU, despite the harmonized legislation, the practices concerning safety issues differ among the member states. In addition, the non-uniform national market surveillance in EU member states may enable dishonest operations.

This paper discusses the results of a study on managing safety-related compliance in differing market areas, especially the market areas of the EU and the USA, from the perspective of European companies. The focus is on the differences between the regulatory frameworks for product safety, especially machines for use at work and the possible problems in these two markets. The data were gathered with a literature review and interviews. The interviews were conducted with representatives of five EU companies that operate worldwide and with representatives of 16 external European organizations that regulate company's compliance.

2 BACKGROUND

2.1 *Machine safety in the EU*

The free movement of products is one of the fundamental freedoms of the European internal market (European Parliament 2017). Thus, the legislation and standards for machinery are mostly harmonized within the EU member states. In the EU the Machinery Directive promotes the free movement of machinery within the European Single Market (European Commission 2017a; Rausand & Utne 2009). The Directive and the supplementary harmonized standards define clear requirements and guidelines for safety during the design process of most machines (Baram 2007; Rausand & Utne 2009). If a company's product complies with the relevant safety requirements, it will avoid product liability claims for defective products.

The Machinery Directive is a total harmonization directive. It defines the essential health and safety requirements that machinery must fulfill in order to be placed on the market and the conformity assessment procedures to demonstrate that a machine fulfills these requirements (European Commission 2017a; Machinery Directive (2006/42/EC)). The aim of the directive is to help machine producers to ensure the safety of their products.

An EU member state may set additional requirements consistent with the Machinery Directive, but freedom of movement must still be assured (Baram 2007). In addition, national authorities carry out market surveillance of products. However, there is general coordination by the European Commission, EC (European Commission 2017b).

Overall in the EU, the essential requirements for the health and safety of products are specified in directives compiled by the EC. The standardization complements the legislation, and this system linking standards with legislation is unique in the world. European standardization bodies, such as the European Committee for Standardization (CEN), are responsible for compiling the standards and technical specifications to meet the essential requirements of the directives. Standards that are linked to directives are referred to as harmonized standards. The EC mandates and approves them. (European Commission 2017c) Applying the standards is voluntary for the manufacturer, but the manufacturer has an obligation to prove that a product conforms to the essential requirements (Europedia 2011).

Several harmonized standards have been replaced by international standards, such as the International Organization for Standardization (ISO), for example. These standards have the same role in the EU as the harmonized standards. (Murthy et al. 2008)

2.2 *Machine safety in the USA*

The market of the USA is not as uniform as in the EU. In the USA, Congress is the legislative branch of the federal government and makes laws for the nation. In addition, federal agencies, federal courts, as well as state and local governments, issue regulations, decisions and laws. (United States Government 2017) From the perspective of safety regulation, an important party in the USA is the Occupational Safety and Health Administration (OSHA) that is organizationally under the United States Department of Labor (Occupational Safety and Health Administration 2017).

In the USA, the concept of product liability is central, but there is no federal product liability law. The laws of each state determine the liability of a product. (Mondaq 2017) General conformity marking for products in the USA similar to the CE conformity mark required in the EU is not applied. However, warnings on products have an important role in the USA. The aim of the required warnings is to alert consumers to the existence and nature of product risks. (Cemarking 2017)

In addition to complying with technical regulations, a product must comply with the private sector standards. There are several standards development organizations in the USA. (American National Standards Institute 2017) However, many operate under the umbrella of American National Standards Institute (ANSI), which coordinates the development of standards in the USA (American National Standards Institute 2017; International Organization for Standardization 2017). The standards may require the application of different conformity assessment measures to demonstrate compliance with a standard. The standards are technically voluntary, but failure to meet relevant standards could result in lawsuits. (American National Standards Institute 2017)

2.3 *Managing compliance*

Compliance with the requirements indicates that a company conforms to the stated and applicable external requirements concerning it and its products and/or services (e.g. Carroll & McGregor-Lowndes 2002). If compliance is not achieved, risks may be realized, such as fines, indemnities, bans on business operations or loss of licenses (Ratsula 2016). Compliance management can be defined as ensuring that business processes, operations and practices are in accordance with a set of prescribed and/or agreed requirements and fulfill general ethical and moral principles (Sadiq & Governatori 2010).

Compliance management should not be a distinct activity but part of the business practice (Sadiq & Governatori 2010). The aim in machine manufacturing should be to achieve compliance by design (Ratsula 2016; Sadiq & Governatori 2010; Lu et al. 2008). Companies can also try to influence future requirements (regulation, standards etc.) beforehand, by trying to affect the requirements in force or their enforcement (Tala 2001; Henson & Heasman 1998).

A regulated model may be applied to indicate compliance. In the EU, a CE marking signifies that a product complies with the safety, health and environmental protection requirements of the applicable EU directives (European Commission 2017d). As an example, in the EU, for normal machines compliance may be evaluated internally within a company (Murthy et al. 2008). Machines classified as dangerous require an external compliance assessment by an external body called a notified body (Macdonald 2004; Murthy et al. 2008).

3 OBJECTIVES OF THE STUDY

This paper discusses the results of a study on managing safety-related compliance in differing market areas (the EU and the USA) as part of machine design in global business. The scope is companies that design and manufacture machines intended for use at work and focus on business-to-business products. In addition, the role of external parties was examined. The objectives of this study are as follows:

1. to review the problems experienced in managing product safety-related compliance in different market areas, and
2. to review the practices applied to manage compliance in different market areas.

This study strives to provide new information about a practical problem in compliance management in two different market areas and produce a scientific contribution for the scientific community by adding the safety aspect in the areas of managing compliance where it had not been included.

4 SUBJECTS AND PHASES OF THE STUDY

4.1 *Subjects of the study*

The main data used in this study was collected between 2011 and 2015 as part of a larger study on managing safety-related compliance in a global market. The study presented in this paper was conducted at Tampere University of Technology in cooperation with five companies that manufacture machines intended for use at work, ten Finnish external parties and six European external parties.

The companies have significant operations in Europe and Finland. Two companies were the main subjects of the study with a broader examination. Four companies manufacture business-to-business products covered by the Machinery Directive. The products of one company do not need to adhere to the Directive, but the company uses it as a support in their design.

The external parties were Finnish and European organizations that formulate and/or influence EU legislation and standardization. The Finnish external parties represented ministries, authorities, a standardization organization, an engineering office, insurance companies and companies' interest groups. The European external parties represented legislators, standardization organization and interest groups.

4.2 *Interviews*

The data was collected in interviews. The interviews were semi-structured, including pre-prepared, open-ended questions. Each interview covered the topics in a similar sequence. The interviews with the companies' representatives were individual and group interviews. However, the group interviews resembled discussions.

The representatives of the external parties were interviewed individually. The interviewees of the companies represented experts from product safety, design and product line organizations. Overall, interviews were conducted with 34 company representatives and 53 external party representatives. The topics of the interviews were in accordance with the study's objectives. The qualitative data of the interviews was first analyzed separately from the companies' and external parties' points of view. The results were merged and complemented with the results of the literature review.

5 RESULTS AND DISCUSSION

5.1 *Problems in managing compliance*

An essential difference between the market areas of the EU and the USA is the different legal traditions. This causes difficulties for the participating companies. The EU's legal tradition is based on civil law and the USA on a variation of common law. In addition, in the EU product safety legislation is mostly harmonized, and in the USA, it is mostly state-specific. In the USA, product liability is central, and warnings on products have a very important role (see Mondaq 2017). The negotiated Transatlantic Trade and Investment Partnership (TTIP) agreement between the EU and the USA should help exports, but the future of this agreement is very uncertain (see European Commission 2017e).

Although the EU seems to have harmonious legislative requirements concerning the safety of machinery, most of the participating companies' representatives experienced variation in the practices, requirements and enforcement among member countries. In the EU, separate parties carry out market surveillance nationally (see European Commission 2017b). The market surveillance by authorities was not experienced to be uniform and truly effective within the member states of the EU. However, the companies' expectations for the external parties seemed to be controversial. The authorities do not check products before they enter the market. The companies mentioned that there is no official external body from which to seek support for interpretation of requirements. In proportion in the USA, the same agencies draft and inspect product safety requirements.

In the EU, standardization and standards have a specific role. There is a unique monostandard system, and the standards are strongly connected to the legislation (see European Commission 2017c). However, the standards are still officially voluntary. The companies in this study actively participate in standardization drafting committees. European standardization organizations cooperate with international organizations, such as the ISO. However, the interviewees mentioned as a difficulty that the ISO standards are not commonly applied in the USA. In addition, there is a completely different definition of international standards in the USA; the standardization organizations may be private competing parties, and the standards may be mandatory.

The participating companies find the USA market particularly difficult from the European perspective. There is more state-specific regulation and a completely different framework for safety issues. If an accident or harm occurs in the USA market, the court considers whether a company has manufactured safer products for other markets because of other requirements of that market. However, specific contracts are essential in business-to-business products. Consumer products seem to be more problematic, because the fear of a class action in the USA.

A new issue is that the political situation will probably affect foreign companies' exports to and operations in the USA. The negotiated TTIP agreement for trade and investment between the EU and the USA has run into difficulties, and its future is unknown.

5.2 *Compliance management practices*

European integration has clarified companies' operations significantly within the EU. The companies' representatives consider that compliance with European product safety requirements, such as the Machinery Directive, is a good basis for engineering the machines for other markets as well. In addition, the related CE marking of machines is well-known in other market areas. However, if the business is truly global, the demands of the tightest market need to be followed primarily. The companies consider that they must be especially well prepared for the USA market because of the differences in legal traditions.

The external parties' representatives brought up the need for a comprehensive risk management policy for the USA market. Companies should also have local legal advice in the USA to tackle local requirements most effectively. In addition, the external parties stated that exporting to the USA market with only a small number of products is not recommended because of the careful preparations and local testing. The binding requirements may be petty in the USA, but the role of the legal system is important in the market (see American National Standards Institute 2017; Mondaq 2017). However, in the USA consumer products may typically cause more difficulties than business-to-business products. Concerning business-to-business products, contracts have an important role in responsibility issues, and mastering contract techniques is crucial.

The basis for achieving compliance is that when a company operates globally the personnel participating in the product development need to be aware of universal product safety requirements and local requirements of the market areas. New local information typically comes from different sources, from customers and via new orders, from maintenance, from local front lines and dealers, as well as from benchmarking situations with other companies. The companies' representatives stated that it helps if their representatives participate in the process for drafting requirements, such as standardization committees. Participating companies may have an edge over competitors (see Tala 2001; Henson & Heasman 1998). However, for European companies direct participation and influence are possible mainly only within their own market.

Localizing products by manufacturing companies may be carried out by identifying and taking local requirements and needs into account during the initial design and manufacturing of the machine or meeting the requirements locally at the front line. Dealers may also make local changes for products. However, the parent company should be aware of these actions because responsibility may be unclear if something occurs.

6 CONCLUSIONS

The core of this study was the management of product safety-related compliance in two market areas, the EU and the USA. The results of this study are based on the views of five machine manufacturing companies in the EU regarding problems the companies have encountered while managing compliance and their practices for managing compliance. In addition, the roles of national and European external organizations that affect companies' management of compliance were considered.

According to the results, the differing legislative frameworks and legal traditions are problematic for the participating companies. The companies are somewhat afraid of the USA market due to possible legal actions. However, to avoid issues, a comprehensive risk management policy and local legal advice sourced in the USA are recommended practices.

As a conclusion, the differing requirements between market areas may hinder exporting. Machine manufacturing companies operating in several market areas need tools and practices for recognizing and applying safety requirements more effectively. The topic of managing compliance needs to be followed up continuously because the situation is variable. As an example, the changed political situation in the USA will probably affect European companies' exports to and operations in the USA. In addition, the long-negotiated TTIP agreement between the EU and the USA has run into difficulties. In comparison in the EU, Britain's probable coming exit from the EU will affect the future of the European internal market as well.

This study provides an overview of problems of and practices for managing safety-related compliance in two market areas especially for companies that operate globally. These results may be applied by firms that are developing their own operations. The focus in this study was a specific industrial sector and business-to-business products. In the future, studying similar issues in other contexts and other types of companies would be valuable.

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Occupational safety and health and environmental safety criticalities depending on geo-economic areas: A focus on mining and quarrying activities

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ABSTRACT: International and National databases confirm a global inequality in terms of financial, economic and social development of Countries, despite the World Globalization process of International integration by the interchange of worldviews, knowledges and cultures. Such mismatches are even more evident between the low-income countries and the "rich" ones, where techniques, technologies, geopolitical economies, and normative frameworks are strengthen. Unfortunately, these aspects somehow affect the working conditions in critical NACE sectors, where the occurrence of work related injuries is still impressive.

The mismanagement of OS&H aspects is related to a lacking management of emissions toward the surrounding territory, contributing to determine important environmental impacts; this is more evident in high-risk activities such as Mining and Quarrying—M&Q.

The present work aims to provide some useful tools to manage OS&H and Environmental issues in M&Q, a sector where the involved techniques and technologies significantly depend on the economic and cultural context.

1 INTRODUCTION

Sustainability of anthropic activities in relation to the human wellbeing and the environment represents a key issue of 21st century. The correlation between the level of development of our society and the potential relapses on the workers' rights and safety and on the environmental quality is well-know. These complex phenomena affect populations and territories both at global and local scale. International and National databases (i.e. ILO, EU, OSHA) confirm the widespread inequality in terms of financial, economic and social development between countries even though the ongoing process of International integration by the interchange of worldviews, knowledge and cultures. Whereas inequality involves both developed and developing countries, the mismatches are more evident between the "rich" and the low-income nations, where technical, technological, geopolitical, economical and normative issues are more evident.

Unfortunately, such driving factors determine direct impacts on working conditions and environment especially in critical NACE sectors. While the occurrence of work-related injuries is still impressive, at least in terms of incidence rate, the relapses of work-related issues determine also impacts on the surrounding territories. To face such criticalities, a synergic effort of international policies and specific approaches is necessary.

The present paper aims to provide some useful tools to manage OS&H and Environmental issues in Mining and Quarrying—M&Q, a particular sector where the involved technical, technological and human resources significantly depend on the economic and cultural context. In the first part the Authors present a summary of the main results from the consulted databases, in order to determine the severity and the diffusion of these issues. The second part provides an approach, special for emerging economic countries, based on the essential role of a dissemination of the Culture of Occupational Safety, implying full synergy of management and employees, as actors with different tasks and skills but with a common target. Moreover, is proposed a simplified tool for the analysis of issues related to the environmental impact of M&Q activities, with a particular focus on Small and Medium Enterprises—SME. By focusing on developing countries, indeed, smaller businesses have generally more difficulties in complying with the environmental legislation, which is often very unspecific and targeted to reduce and prevent environmental impacts on a large scale.

The final target of such approaches is to improve the understanding of the interactions between cultural, operational and contextual variables as a pivotal requirement for an effective Risk Assessment and Management considering Occupational and Environmental compartments in different scenarios.

2 STATISTICAL ANALYSIS ON M&Q DATA

According to the International Labour Organization—ILO (ILO source), more than 330 million work-related accidents occur worldwide every year. These statistic data might certainly underestimate the real number of accidents, because of lack of data on illegal workers, not reported injuries, etc. From the same source, a total amount of over 2.4 million fatal accidents every year is reported for unsafe or unhealthy workplace conditions. Worldwide, this causes a loss of 4% of global Gross Domestic Product—GDP.

The ILO's data on work related accident at national scale (ref. period 2010–2015) confirm that the gap in terms of financial, economic and social development between countries with different income levels have consistent relapses on the Safety and Health conditions of workers. Fatal accidents data in the three most critical macro-activities (mining and quarrying, construction and manufacturing) underline variability for the mean Incidence Rate values (Incidence Rate is the average number of new cases of fatal occupational injury during the calendar year per 100000 workers in the reference group). The indicator is high for lower middle-income countries, and decreases for upper middle and high-income countries (Fig. 1).

From the same database, the results of statistical analysis on fatal accident occurred in mining, construction and manufacturing activities are also summarized for the different income countries groups during the time interval 2010–2015 (Fig. 2). The indicator, for mining and quarrying, results

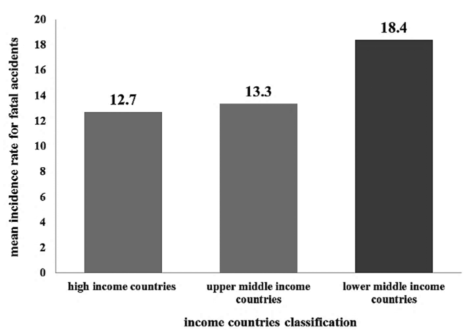

Figure 1. Mean incidence rate for fatal accidents in mining and quarrying, construction and manufacturing activities (source ILO).

the highest in all the income categories, as a confirmation of the criticalities of this sector.

Focusing on M&Q, a former publication by ILO (ILO, 1999) reported a total number of 13 million employees in the sector worldwide, with prevalence of workers—at that the beginning of 21st century—in the developing countries: 55% in Asian and Pacific region, 29% in Africa, 12% in Latin America and 4% in developed nations. The same document, through questionnaires distributed to governments, employers' organizations and mining unions, also evidenced (Fig. 3) that the first perceived major issues are OS&H (18%) and Environment (13%). This result has probably increased in recent years due to the arising focus on such topics as previously described. However, the Authors have not found recent available and comparable researches.

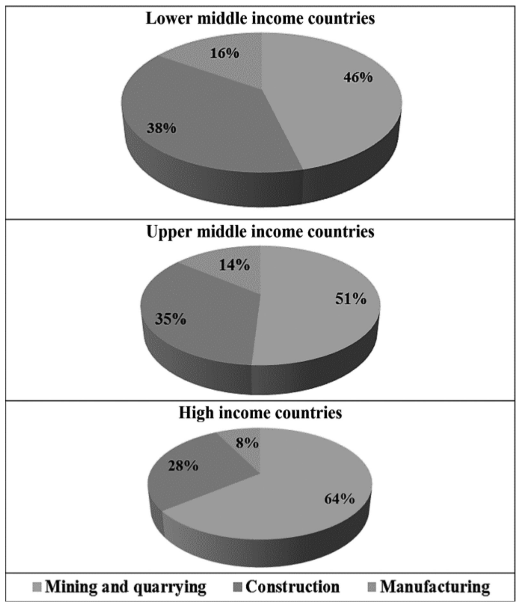

Figure 2. Fatal accident incidence rate for different sectors (source ILO).

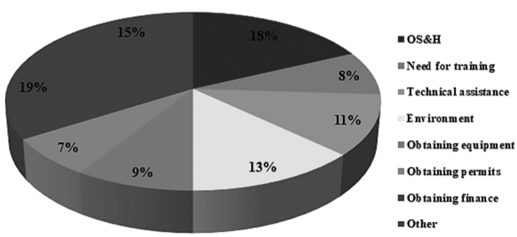

Figure 3. Results of questionnaires on perceived major issues in mining and quarrying (ILO, 1999).

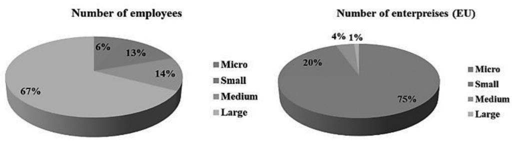

Figure 4. UE n° of employees (left) and n° of enterprises (right) (UE, 2016).

Over the previously described effects of socio-economic conditions among nations and technological developments among macro-activities, another factor conditioning OS&H and Environmental criticalities is represented by the size, and the number of employees, of M&Q activities. In Europe (Eurostat, 2016), most of quarrying and mining workers are employed in large enterprises (>250 employees) (Fig. 4 left). In Italy, the situation is slightly different since the 60% of workers is employed in the SMEs. However, by considering as an indicator the number of companies, it can be observed from the previously cited report that almost the 75% are by micro enterprises (<10 employees) (Fig. 4 right). Considering also the small ones (10–15 employees), the number of companies represents the 95% of the total amount. Such data is particularly interesting when related to the potential risk of damage and annoyance relapses to anthropic and environmental compartments and for the sustainability of resources management. Referring to other continents, former data (Chaparro Avila et al. 2000) reported a total amount of over 275000 small-scale mining activities in BRICS countries (Russia excluded).

The Authors observed in the consulted databases and publications, the frequent lack of data, both on OS&H and Environment issues, for low-income countries. In particular, the complete absence, in the ILO database, of data on work-related accidents shows that OS&H aspects in low-income countries might still remain poorly considered, also taking into account the expanded data sources (administrative records, economic or establishment census, establishment surveys, household surveys).

3 AN APPROACH BASED ON THE DISSEMINATION OF CULTURE OF SAFETY

A virtuous mining and quarrying situation can be achieved only where an effective General Risk Analysis is correctly performed, the Sustainable Development itself being the result of such approach (Fig. 5). Some parameters condition the operation quality:

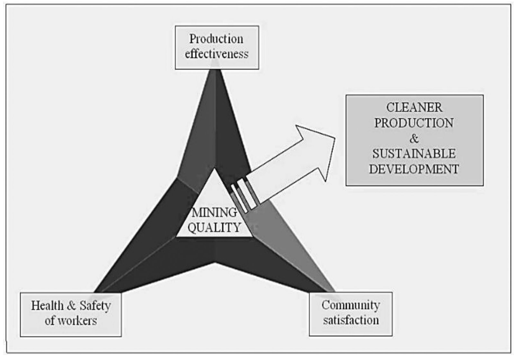

Figure 5. Main parameters conditioning the M&Q quality.

- Production effectiveness: high recovery, efficiency and productiveness, reliability of the product output, no sanctions;
- Safety and health of workers: accident prevention policy, limitation of interferences, reduction of noise and airborne dust, emergency management;
- Community satisfaction: clean air and water, reduced ground occupation, environmental rehabilitation, community health, occupational possibilities (Martinetti 2013).

Moreover, Safety and Health of workers should be considered a key topic from not only an ethical point of view, but also where the overall mine effectiveness is taken into account, since accidents and health impairments dramatically affect both the direct and indirect costs of production, and the Company image.

An effective Risk Assessment and Management, especially in the emerging economies countries and high-risk activities as M&Q, should take into account the coupling of cultural and contextual variables interactions. A widespread Culture of Safety leads at the very base of an effective Risk Assessment and Management, implying the full synergy of management and employees as actors with different tasks and skills, but with a common target.

In the last years, the Italian extractive sector showed important decreases in the production, especially involving small mines. With reference to the occupational level and the Safety and Health aspects, during the 2014 in Italy more than 30000 workers were involved in the M&Q activities, and Eurostat recorded about 500 accidents (incidence rate equal to 1,3). The Italian regulation on the safety and health of workers at work D.Lgs. 81/2008, directly drawn from the 89/391 EEC Directive on the measures to encourage improvements of the safety and health actions, introduces the Risk Analysis as a mandatory task for the employer.

Where the extractive operations are considered a special "daughter" regulation should be furthermore applied—derived from 92/91 and 92/104 EEC Directives—which integrates the main directive statements with further detailed clauses, and imposes a special Safety and Health Document—DSS.

In the case of temporary or mobile construction sites, the D.Lgs. 81/2008, enforcement of both Frame Directive 89/391 EEC and "daughter" Directive 92/57 EEC, includes general and special requirements to comply. The OS&H is considered from the input data in the feasibility analysis step, thanks to precise Safety professionals (Coordinator for safety and health matters at the project preparations, and execution, stages) and Safety documentations (Safety and Health Plan drawn in the design phase, and Safety and Health Plan at execution stage).

In the case of mining and quarrying activities, the Italian enforcement of the 92/104 EEC Directive is not included in the D.Lgs. 81/2008; as a consequence often the OS&H aspects are considered just in the DSS, devoid of any Risk Analysis approach, that as to be presented at the beginning of activities. Even though the DSS corresponds formally to the Safety and Health Plan at execution stage, the resulting situation is potentially confounding for some *self-proclaimed* Risk Analyzers.

Therefore the Safety and Health problems in M&Q should be carefully considered from the very first phases of the activity design and must be set in force at the beginning of the exploitation activities. An effective Risk Analysis, upon which the activity plan and management should be based, involves a pro-active approach, taking into account the Risk Analysis improvements and revisions.

3.1 *Culture of safety, general aspects*

It is important to integrate OS&H at the different levels of education as promoting a safety culture in the workplace is not just about ensuring that shop floor workers learn how to act safely. Modern OS&H legislation is goal-setting and follows a non-prescriptive risk-based approach—risks must be assessed and appropriate measures put in place. All parts and all levels of industry and business need to understand how Risk Assessment and Risk Management are essential to good business management.

Future practitioners (e.g. designers, engineers, doctors and other health professionals, managers and supervisors at all levels, right up to the director level) are among those who need relevant education about their future OS&H roles and responsibilities. This need is more evident for civil engineers who will have legal duties regarding the design, planning and execution of construction projects. (De Cillis et al. 2016)

Culture of Safety has a key role in advanced approach for Safety Management (Pillay 2015) and it is both framed and reflected in organizational policies, business processes, and allocation of resources usually originating at board or senior management level.

3.2 *A cultural change approach for mining and quarrying in emerging economies*

In the case of emerging economies, the improvement of Safety and Health conditions of M&Q workers is possible through a real and concrete cultural change on OS&H involving all actors, from governments to company managers up to workers. A more consciousness on Safety problems and the benefits deriving from a careful Prevention can be the starting point to enhance the OS&H conditions, giving rise also to a better economic (but not only) resources allocation. This results particularly beneficial for M&Q small and medium-sized enterprises, often characterized by reduced budget and resources' availability.

An actual cultural change in OS&H policies can also lead to technical and behavioral enhancement, thanks to the increased awareness on the specific OS&H problems and the better knowledge of available tools and methods (Risk analysis approaches) to reach the most suitable solutions to control Risks.

The implementation of the approach based on the dissemination of Culture of Safety, as mean to achieve an effective cultural change, necessitates the support of solutions to face problems often affecting the SME in low-income countries:

1. Adoption of accident data recording systems

A crucial part of every prevention strategy is to have a clear knowledge of the number of work-related accidents and diseases, their severity, the causes, and the workplaces and industries where they occur. This means that every country needs a well-functioning and effective system for reporting accidents and diseases and for analyzing the resulting database (Lucchini & Landrigan 2015). As results from international databases, no data on work-related accident are available for low-income countries. Nowadays, some user-friendly systems special for extractive activities, make available reliable input data drawn from occurred accidents, essential for the development of an exhaustive Risk Analysis and Management in the Prevention through Design pro-active approach (Martinetti et al. 2012).

2. Knowledge of available international Safety regulations

The cooperation of international organizations (e.g. ILO) becomes of paramount importance to spread the knowledge on available international Safety regulations in order to promote governments to issue Safety laws, trying to align the international legislation, providing a kind of large scale dissemination of Culture of Safety. Seminars, study days, conferences can be important opportunities to present and discuss international guidelines such as International Labor Organization Conventions (e.g. code of practices Safety and health in opencast mines, Safety and health in coal mines, Guide to the prevention and suppression of dust in mining, tunnelling and quarrying). The adoption and ratification of such a Safety regulations represents the first step for the implementation and improvement of national OS&H policies. At the same time, workers have the opportunity to deepen the knowledge about their rights and the educating employers on their responsibilities under the Occupational Safety and Health.

3. Safety: Everybody's responsibility

Official Safety regulations, and technical Standards, Guidelines and good practices should address the OS&H company policies. Company managers decide on the company's Health and Safety policy to adopt, Safety performance of the organization, safety leadership, employee engagement and safety related behavior. However, it is necessary to recognize "that, while having engineered safeguards and formal management systems to control risks is essential, it is equally important to win the commitment of the workforce to treat safety as a priority through a genuine corporate commitment to achieve high levels of safety" (International Nuclear Safety Advisory Group, 2002, Foreword). Therefore, an effective approach to achieve a cultural change on OS&H aspects requires a bottom-up system based on a proactive cooperation of the figures involved in OS&H system, by means of "circular" information flow, employee accountability and proactivity from the bottom. Cultural and interdisciplinary exchanges for both Safety professionals and workers in mining and quarrying activities, engaging staff from high-level income countries, can improve the bottom-up system getting ideas and enhancement suggestions.

4. Increase number of available trained OS&H professionals

The effectiveness of the bottom-up approach, requiring the cooperation of all actors involved in OS&H system, needs an increased effort on education and training, in many of low-income countries: in Tanzania less than 10 OS&H professionals currently exist in the entire country (source ILO).

5. Key role of workers

In the bottom-up approach, very different from the top-down one controlled by hierarchy and prescriptions, workers assume a key role in training action and in the resulting improvements on Safety, and they become active and proactive personnel for the different phases of the problem solving process (reporting the problems they encountered by increasing their level of attention and their ability, identifying hidden problems, offering their own contribution in finding solutions, participating in the implementation of the solution adopted).

The five steps are necessary to achieve an improvement on OS&H conditions also in emerging economy countries, by means of bottom-up system at the basis of Culture of Safety, fundamental to carry out the cultural change towards a greater awareness of Safety and Health.

4 A PRACTICAL TOOL TO ASSESS THE ENVIRONMENTAL IMPACTS OF SME MINING AND QUARRYING ACTIVITIES

Concerning the environmental relapses of M&Q activities, the framework delineated in paragraph 2 by the databases' analysis confirms the initial hypothesis of synergic contributes between economical and context factors. Regarding the M&Q sector itself, the most important pressures consist in the emissions of air pollutants and noise (consistently depending by the mining technologies employed) in open-pit mining (Patra et al. 2016) activities, while in underground mines water consumption and pollution of ground water (Price & Wright 2016) and soil are dominant. Other indirect pressures over entire territories are represented by the traffic of vehicles for the transport of goods and workers and the alteration of the landscape. These and other site-specific pressures acts frequently in synergy to determine a loss of quality of territories and to direct damage and unwanted health impairments also without exceeding normative requirements. An example is constituted by disturbance and annoyance which can be determined by the synergy of the different contributes of pressures related to the activities (Bo et al. 2016).

The issue in the definition of standardized approaches for the assessment of the environmental impacts for the M&Q sector is evident. However, recent studies (Lodhia & Hess 2014; Hodge 2014) determined that the competitiveness of the sector does not depend only on the valued added of the production but also on its impacts on environment and land. In such context, small enterprises have more difficulties in complying with environmental legislation and on proposing quality approaches rather than large companies. Often the environmental legislation is very unspecific and targeted to reduce and prevent environmental impacts on a large scale. Thus it does not take into account specifically the small activities (European Commission, 2010). This difficulty is even more significant for enterprise which work in low and middle income countries.

The proposed method was developed and validated by the Environmental Safety group of DIATI (Politecnico di Torino) to respond to similar needs arisen in other working sectors (Bo et al. 2015; Pognant 2017). The method is based on an adaptation of the DPSIR (Drive Pressure State Impact Response) framework developed by the European

Environmental Agency (EEA, 1999). Through a classification of environmental indicators, it was developed to simplify the process of impact assessment related to the implementation of projects on territories (European Union, 2014). The research group have modified and adapted it, in order to allow its application also in small activities. In the shape of the developed method, it has been adapted and proposed here in order to allow the assessment of the impact of small-scale M&Q activities.

The first stage of the analysis consists in the description in detail of the objects of analysis. Each mining activity should be divided into process phases, sub phases and elementary processes. This division allows the identification and description of the operational and technical choices that were identified for each phase. Once the activity was described, for each elementary process the drivers that could cause an impact on the environment have to be identified. The drivers were defined dividing them into: used machinery; materials (raw and complementary materials, waste and products); work environment (macro and micro); work organization (general organization and operative conditions) (Fig. 6).

For the mining activities the more significant drivers are the excavation types (surface or underground mining), the used machines, the used resources (above all the amount of water) and the produced waste.

The innovation of the approach is in this phase of analysis. The breakdown of each work phase, easy feasible for SME, allows a simplification of the following phase of analysis and to better quantify the pressures and the impacts.

Table 1 shows by way of example, the application of the method to a SME sand quarrying activity (the table shows only one main phases among the different working activities).

This table is the first phase of the analysis. Keeping this division to each identified driver,

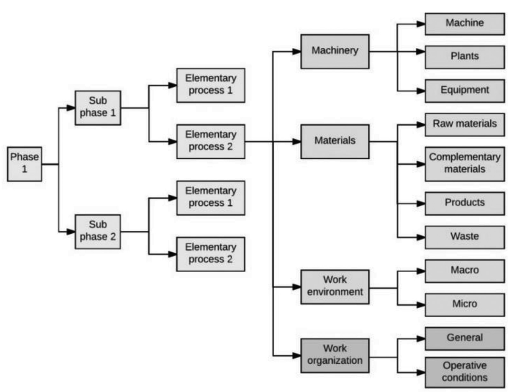

Figure 6. Analysis scheme for SME activities.

Table 1. Example of suggested method application.

Main phases	Sub-phases	Elementary processes	Machine	Materials				Work environment		Work organization	
				Raw materials	Complementary materials	Products	Waste	Macro	Micro	General organization	Operative conditions
Sand excavation	Mining from the excavation face	Digging Loading of the material Unloading of the materials	Excavator	Sand	Fuel	Sand pile-up	Oil and fuel loss	Excavation area	Excavation face	8 h/d activity	1 worker steers the excavator
	Transport of the material to subsequent processing stages	Loading of the material Transport to the following phases	Dumper						Loading area		1 worker steers the dumper

the corresponding pressures have to be identified. Associating each pressure to each elementary process allows to facilitate is qualification and quantification. The quantification of the pressures can be done through measures or modeling (US EPA, 1995), according to the features of each considered pressure. To define the pressures not only what can provide an immediate impact, but also what can cause an alteration of the environment in the long term, have to be considered.

The environmental state must be defined by a set of indicators that allows by their observation through time to determine its possible alterations. The indicators are divided according to the environmental sphere of influence (hydrosphere, biosphere, lithosphere, atmosphere and anthroposphere). The choice of the indicators to consider should allow an easy, but complete, identification of all the possible impacts on the territory. The chosen indicators must be assessed, if possible before the start of the mining operations, during the activities and to their conclusion in order to have a clear overview of the impacts on the territory.

Once the pressures and the state have been defined, the following phase of the analysis foresees the identification and, possible quantification, of the impacts on the territory. While the first is quite easy once the pressures were defined, the secondo is not an easy task to achieve. The proposed approach aims in a first phase of the analysis to achieve only the first objective, because a complete identification of all the possible impacts should allow to the small mining activities a first overview of theirs impacts on the territory. Meanwhile once the impacts were defined is possible to provide the preventive and protective responses to put in place.

5 CONCLUSION

The paper aims to suggest some suitable solutions to manage OS&H and Environmental problems in Mining and Quarrying activities, whose criticalities are worsened by cultural and economic difficulties of the considered context.

An actual improvement of OS&H conditions in M&Q is possible by means of a cultural change towards a greater awareness of Safety and Health issues. The dissemination of Culture of Safety, starting point for the cultural change, should take into account the difficult level of development of emerging economy countries and the peculiar OS&H criticalities of M&Q activities. Key points for an actual cultural change include the possibility to record work-related accident data, the availability of Safety Regulation, the consciousness that Safety is everybody's responsibility, the adequate number of trained OS&H professionals and the key role of workers in the bottom-up system.

The second presented approach had the dual objective of a complete assessment of the environmental impact and to be applicable both in case of limited economic resources and SME. This aim was not easy to reach because a significant number of parameters, indicators and effects, whose impact is further influenced by the environment state in which it works, should be taken into account. These aspects have been represented in an easy to read analytical structure. It has been schematized as much as possible in order to allow its use also by not experts in the field.

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Integrating safety into mainstream education and professional and vocational training

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ABSTRACT: Occupational Safety and Health (OSH) improvement, requires people to receive OSH education in formal educational and vocational settings, as well as during their professional careers, for example, in the form of "on the job training".

Enforcement of OSH laws in workplace settings has a direct correlation to both management's and workers' level of Safety education and know-how. In any Safety Management System (SMS), Safety education is a key component for the successful implementation of the SMS.

To successfully integrate safety into mainstream formal education systems, various approaches may be followed, such as the holistic approach, that is, the integration of safety issues in school curricula, the safety within course syllabi approach, not limiting OSH education to any one single subject, and the safety via the work environment approach, especially suited to students in technical and vocational programmes. Careful combination and optimization of the above methods in a formal educational system will yield the best results, as various real-life examples show.

1 INTRODUCTION

In order for Occupational Safety and Health (OSH) levels to improve in any society, it is imperative that people receive OSH education in formal educational and vocational settings, as well as during their professional careers, for example, in the form of "on the job training".

Viewed through the eyes of an OSH Labour Inspector carrying out regular inspections, enforcement of OSH laws in workplace settings has a direct correlation to both management's and workers' level of Safety education and know-how. In any Safety Management System (SMS), or in any OSH Strategy, formal or informal, certified or non-certified, Safety education is a key component for the successful implementation of the SMS. This paper examines the various approaches used to successfully integrate OSH into mainstream educational systems in various countries in Europe as well as elsewhere. Regardless of the approach adopted, the teaching of safety and health attitudes and behaviour to children and young persons and the development of their knowledge about risks and risk prevention is paramount to the integration of OSH into the education sector. This must include measures to safeguard the safety and health of staff and students in all educational undertakings.

2 APPROACHES TO INTEGRATING OSH IN EDUCATION

2.1 *Holistic and whole school approach*

Starting in 2002, within Europe, the strategies implemented in educational establishments of Member States have evolved from holistic approaches which aimed at integrating safety and health issues in the school curricula to the notion of Whole School Approach. This requires the management of health and safety of students and staff to create a healthy learning environment. Students are part of an environment with a safety culture. The concept of the Whole School Approach brings together, at each school, the management of the education community and relationships with parents, local authorities and institutional stakeholders. Such an approach guarantees health and well-being for students in the school environment as well as in their future lives in workplaces and in society. Therefore, the Whole School Approach regarding OSH achieves –

- Combination of risk education and safety and health management in schools for students and staff
- Integration of risk education, health education, safety management and the healthy school concept

- Active involvement of students and staff in school safety management
- Training and involvement of teachers in OSH management, improvement of their understanding of OSH and development of practical skills, which improves their ability to provide risk education to students
- Developing students' understanding of OSH
- Involving students in hazard identification and proposal of solutions.
- Integrating risk education and school safety and the way it functions in all school activities, making it part of school life.

The various case studies of this approach in educational establishments throughout Europe have shown encouraging results. In each case, OSH skills were developed (teachers, staff, students), partnerships were built, OSH involvement of students and their compliance with safety rules increased, as well as specific actions tailored to the educational setting were undertaken. The real-life cases demonstrated that risk education and safety management can be combined in practice.

The difficulty with the Whole School Approach in University level educational facilities lies in the fact that such establishments are usually under different national authorities, dissimilar to schools, which need to be convinced to include OSH in degree and professional programmes. Compounding the problems are the lack of OSH resources and lack of partnerships with university faculties and professors. Last but not least, the need to improve OSH culture and resource sharing.

2.2 *Safety within course syllabi in schools*

This approach introduces OSH in the school curriculum, targeting each course syllabus separately. The immediate benefits of this are-

- enables the teaching of OSH to become systematic and a sustained part of the whole school educational process and not just dependent on the enthusiasm of individual teachers
- sets the context for actions, partnership development, etc.
- promotes the development of resources (training materials and training for teachers)
- puts it on the agenda and helps to make it a priority, and provides motivation for action
- can provide funding for development, implementation and evaluation of activities
- stimulates action by interested, non-governmental partners
- provides the context for setting standards for risk education.

Many EU Member States have OSH modules included in the curriculum at various stages of education, in varying stages of development. Recently, there has been a focus on including OSH in a cross-curricular manner across many different school topics, and also in developing the specification of key competences in OSH for pupils, students and teachers.

It is easy to determine that the inclusion of OSH in the school curriculum has certain disadvantages. Firstly, there is limited room in the timetable for additional core subjects, so education ministries cannot realistically be expected to make risk education a core subject. Secondly, good health and safety is a practical matter—knowledge has to be applied. So the learning is often more meaningful and the lesson better conveyed to students if it is applied to another real and meaningful situation, such as safety issues in physical education, the use of computers or other practical activities. Thirdly, topics related to matters such as developing responsibility and acting as a good citizen have become part of the core curriculum. It is important that students at a young age develop such values in relation to OSH, especially in order to promote a safety culture at work. Fourthly, OSH is often perceived to be a rather dull topic. However, there is an opportunity to make it more interesting by, for example, making it the subject of painting tasks or poetry.

2.3 *Safety via the work environment*

This approach focusses on the transition of students to work environment and educating them so that OSH plays a key role their new work life. It is especially suited to students in technical and vocational educational establishments. It usually includes modules such as occupational risk prevention methods and approaches, first aid, working movements and postures, work permit schemes (e.g. for carrying out hot work), safe driving, safe operation of machinery, safe working at height. It may form part of a policy of lifelong learning, enabling students and staff to acquire skills throughout their education and their working careers. It is however, not immediately applicable to non-vocational or non-technical courses of study.

3 CONCLUSIONS

The integration of OSH into mainstream education is a multi-faceted issue and there is no single approach that can achieve the perfect result. In most cases, a combination of approaches may be the best way forward. For a combined approach to achieve maximum results, various policy areas must be considered such as health education, mental health, social development, sustainable development and environmental education. The key to success is the involvement of teachers (or professors), staff, students, parents, administrators and relevant educational authorities. Risk education and the creation of safe and healthy schools must be part of the OSH framework in the education sector. Synergies must be developed so that the duties of schools regarding OSH management are helped by the actual involvement of students and teachers. Leadership by the school head (or administrator) committing to OSH in the school environment is important to all stakeholders, just as proper OSH training is for teachers.

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An experience of university education on occupational safety and health at Politecnico di Torino

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ABSTRACT: According to the European statistics on work related accidents and health impairments, the general situation still remains critical. In Italy approximately three fatalities/day are recorded. The causes are poor Hazard Identification, uncritical Risk Assessment and, consequently, Risk Management lacking of a Quality approach. The Culture of Safety is a basic tool to support improvements of the situation. Its dissemination finds important allocation at the University education stage. Moreover, the cooperation programs involving Universities and top managers lay at the very base of Occupational Safety & Health (OS&H) improvements, particularly in critical NACE sectors. Politecnico di Torino provides Bachelor, Master Degree, Post-Graduate Master and PhD courses covering multidisciplinary aspects, with remarkable occupational success. The Authors provide information on organization and contents of a Master Degree course, whose applied part is based on Problem Based Learning, starting from in depth analyses of occurred work related fatalities, targeted to discuss suitable prevention measures.

1 INTRODUCTION

According to the data provided by the European Agency for Safety and Health at Work (Harmonized data on accidents at work collected in the framework of the administrative data collection 'European Statistics on Accidents at Work (ESAW)), the work related accidents and health impairments are a still today critical in the 28 EU Countries. The number of fatalities ranges from 3800 in 2009 and 3350 in 2014, and the standard incidence rate (number of accidents occurred during the year, vs. the reference population expressed in 10^5 persons) varies from 2.52 to 2.32 in the same years. As to the Health aspects, the number of persons reporting a work-related health problem resulting in sick leave, ranges from 35% (2007) to 47% (2013).

Even if the data are somehow approximated, and diversified among the EU Countries, such figures are impressive, even more since the average age of fatal accident victims is 38÷40 years; given a life expectancy of approximately 78÷80 years, the yearly total loss due to work related accidents can be estimated in more than $1.3 \cdot 10^5$ years!

In Italy, an average value not far from 3 work related fatalities/day is still recorded, included the categories of workers not considered by the National Insurance Institute—Inail, despite the national enforcement since 1994 of the 89/391 European Directive on the introduction of measures to encourage improvements in the Safety and Health of workers. Alike, the consequences of the past underestimation of the criticality of overexposure conditions at workplaces—especially to chemical and carcinogenic pollutants—are today dramatically manifest.

The main causes of this situations are:

- the technological context, notwithstanding the important progress also in terms of Safety and Health,
- the changed socio-economic scenario,
- the more and more diversified composition and origin countries of the workforce,
- difficulties in implementing preventive measures in complex and constantly evolving production situations.

However, in the Authors' opinion, the primary cause of the failure lays in the still widespread incapability to act according to the OS&H spirit, logical before than regulated.

We can summarize such spirit in the pivotal concepts of a Prevention intrinsically linked to the design, and a Quality approach to the Management of systems, and to their safety.

Figure 1 summarizes the results of an extensive investigation carried out as expert appointed by the public prosecutor, based on in depth analysis of fatal accidents occurred in industries and yards: the sequence covers poor Hazard Identification (HI)—the Hazard Factor was not recognized, or identified with a too generic description (90% of the cases!)—uncritical Risk Assessment (RA) and, consequently, a Risk Management (RM) inadequate and lacking of a Quality approach.

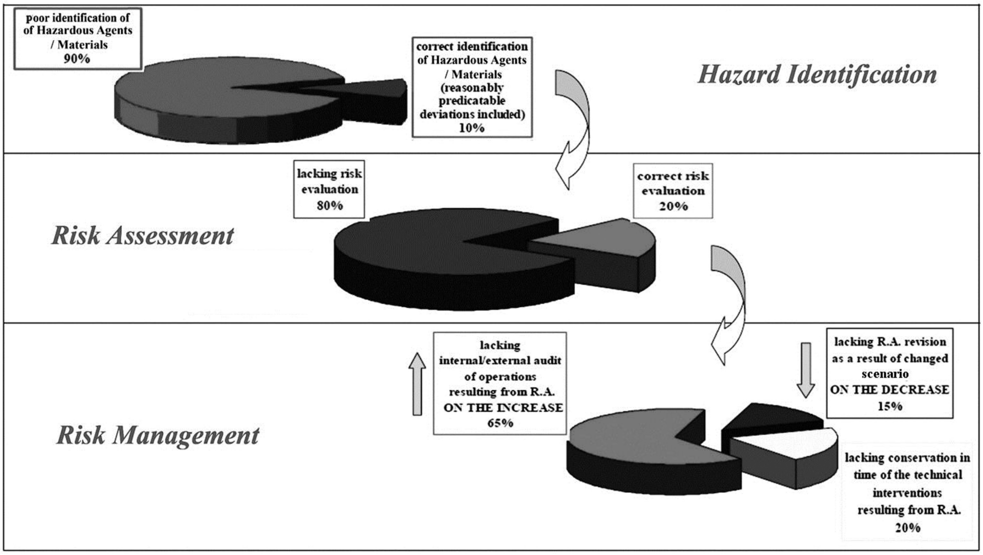

Figure 1. Main causes of fatal accidents occurred in Italian industries and construction yards.

2 IMPORTANCE OF THE DISSEMINATION OF THE CULTURE OF SAFETY

Too often, it is necessary to accept a posteriori the consequences of improvised approaches to the prevention, deriving from:

a. obsolete beliefs that consider only the result of the project, and not the safety of people involved,
b. the still widespread inability of old school decision makers to understand the consequences of technological choices that inevitably will lead, past the long latency times, to irreparable consequences on workers' health,
c. entrenchment behind the stock phrase "*you work to produce, not to improve safety*", whose interpretation of convenience can lead to an objectionable distribution between profit for some, and losses for others.

Far from a formal problem, this involves:

- the use of not repeatable and not formalized Risk Assessment approaches, resulting in arbitrary risk matrices: in some cases, even the exposure duration to a hazard factor, and the number of exposed workers are neglected!;
- a Person Approach focusing exclusively on human errors. According to (Reason 2000), "*to blame people for forgetfulness, inattention, or moral weakness is easy, but useless for the prevention. Effective results are possible only through a System Approach focused on the conditions under which individuals work, to build defenses and avert errors or mitigate their effects*". Leaving behind the Heinrich (1931) approach (Manuele 2013), we can then agree with Richard A. Pollock CLMI Safety Training President speech at the ASSE's safety 2017 seminar, held in Denver, Illinois: "*Accidents do not occur like falling dominos. Causation is multi-dimensional, nonlinear and difficult to predict. Though human error is often the proximate cause, it should never be the starting point of any investigation*";
- the drafting—in the sake of a dangerous "simplification" (the 89/391 EEC Directive, art.9, 2, introduces some simplification of bureaucracy, a concept sometimes misinterpreted)—of generic and cumbersome safety documents and procedures, pasted at the last minute to comply with legal obligation not clearly understood.

Table 1 exemplifies the results of an original computer assisted technique developed for in depth analyses of the events chain leading to a fatal accident (De Cillis et al 2015, Luzzi et al 2015): neglected revision of the Risk Analysis following technical modifications, and consequent lacks in Information, Formation and Training (IFT) of operators and workers appear evident.

According to the main results of an EU survey in many countries, Italy included, OS&H is considered the task of a limited number of professionals (Maida & Patrucco in press). They operate in a context lacking of a widespread Culture of Safety, and not in tune with the multidisciplinary research results that would be essential to understand in depth the special work related safety and

Table 1. Example of the result achieved with the Computer aided Cause- Consequence for Prevention technique.

Accident #	
ACTIVITY SECTOR: C24.10-Steel Production	NOTES: the overhead traveling crane velocity was increased from 3.5 to 5.2 m/s.
CONSEQUENCE → Fatal - Burns	
 *tilted ladle area of the spill*  *effects of the heat wave*	❑ in a steel mill, a modification was introduced to improve the performances of an overhead traveling crane used for the 160 t ladles handling; ❑ the Risk Analysis and IFT of the crane operator were not updated including the new crane performances; ❑ due to the excessive descent velocity, the ladle interfered with an obstacle, tipped and spilled approx. 100 tons of molten steel; ❑ the consequent thermal wave and steel droplets explosion caused impressive consequences and fatal burns to the only worker operating in the area.

		Accident causes chain	Possible corrective actions		
1		Fatal burns	*n.a.*		IX
2		Victim reached by the thermal wave from approx. 100 t of spilled steel	*n.a.*		VIII
3		Ladle tilt and molten steel spillage	*n.a.*		VII
4		Excessive velocity in the ladle handling	*n.a.*		VI
5		Modification of the operating parameters of the overhead traveling crane Procedures/organization of work, Operators IFT	*see III*		V
RM		Poor Risk Management	*Resulting from II, III & IV*		RM
	6	Absence of plant tests after the changes	*Supervising and IFT even for occasional /infrequent crane operators*	IV	
	7	Operation not analyzed after changes, absence of communication between operators	*Revision of the modified plant conformity to the safety standards*	III	
	8	Lacking supervision, absence IFT	*Updated technologies for higher and safer crane performances and ladle handling. Performance and Safety tests on the plant*	II	
9		No revision of the Risk Assessment and Management after the crane operating parameters modification	*Devoted Risk Assessment and Management applied to a plant modification proposal*		I

health criticalities of modern industrial and construction activities, and to identify the suitable countermeasures.

Hence, the importance of the dissemination of the Culture of Safety, as defined e.g. by Von Thaden and Gibbons (2008): *Safety culture is the enduring value and prioritization of worker and public safety by each member of each group and in every level of an organization*.

The Culture of Safety is essential for the effective prevention in ethically, and economically sustainable production systems (see Estimating the costs of work-related accidents and ill-health: An analysis of European data sources—European Risk Observatory): hence, it should be more and more widespread.

Nowadays, the literature on the Culture of Safety is very extensive, so here we propose just some references taken as examples for each of the listed main sub-topics:

1. the value of the Culture of Safety dissemination (in compliance with the Safety and Health Regulations and Standards) (e.g. Hale 2014);
2. starting point: work related accidents and health impairments (e.g. OSHA—DOL);
3. the need of a specific competence in techniques, technologies and OS&H (e.g. Cirio et al. 2015);
4. Culture of Safety at all levels (e.g. Westrum, 2014);
5. goals to reach in terms of basic knowledges/competences of workers and other actors (e.g. Commission of the European Communities);
6. find target (e.g. Almklov 2014);
7. subjects/organizations involved (e.g Safe Work Australia 2011);
8. overview of best practices: Environmental and learning needs assessment, Specific population (e.g. García-Herrero 2013);
9. dissemination of the Culture of Safety in a quality approach (e.g. Eeckelaert 2011);
10. not only information, formation and training, but promotion (e.g. Ewles 1992).

Nevertheless, in some even critical areas, such as the temporary or mobile construction sites (covered by the 92/57/EEC Directive), some gap is apparent, and important improvements are still necessary, as recently highlighted in an international meeting organized by our research group and supported by TELT sas—Tunnel Euralpin Lyon Turin (held in Turin, May, 12th, 2017 about "the basic role of the purchasers of great infrastructural operations in the promotion of the Culture of Safety").

3 THE ROLE OF THE UNIVERSITY EDUCATION IN THE DISSEMINATION OF QOS)

In general terms, since Safety and Health concern everybody, the Culture of Safety should be disseminated to the entire population.

If we consider the subset of OS&H, these concepts should be present in schools of all ranks, and the university education can play a very important role: here the mere discussion of basic criteria and regulatory statements, though necessary, is not enough, and the courses should cover the innovative aspects in the HI, RA & RM in Quality, as resulting by theoretical and applied research work. In this regard, a basic reference is available in the EU report "Mainstreaming occupational safety and health document into university education", 2010. In the following we put into evidence some basic aspects:

> *It is important to integrate OSH into university-level education as promoting a safety culture in the workplace is not just about ensuring that shop floor workers learn how to act safely. Modern OSH legislation is goal-setting and follows a non-prescriptive risk-based approach – risks must be assessed and appropriate measures put in place. All parts and all levels of industry and business need to understand how risk assessment and risk management are essential to good business management. Future designers, architects, engineers, finance officers, doctors and other health professionals and managers and supervisors at all levels, right up to the director level, are among those who need relevant education about their future OSH roles and responsibilities. … This need is more evident for architects and civil engineers who will have legal duties regarding design, planning and execution of construction projects.*

The mentioned document refers to a survey on educational systems in 20 EU Countries (Italy, however, is missing) and in the United States of America. It should be noticed that in some cases education in Safety and Health special for extractive activities is included. The criticality appears evident from the ILOSTAT database: the 2010–2015 fatality index for extractive activities shows values similar to the sum of the indices of all the other activity sectors, construction included!.

Substantially, the survey of the European Agency for Safety and Health at Work highlights the essential role of training in the field of Risk Assessment and Management and of its organization -in some cross cases provided by special Departments of OS&H- and stresses the following topics:

1 *Mainstreaming OS&H into education concerns integrating one policy area—Occupational Safety and Health—into another—education. … Mainstreaming in relation to OS&H at the workplace is about making risk management principles and 'thinking OS&H' an intrinsic part of the way that actions are taken, so that occupational safety and health is not just an additional task;*
2 *Safety and Health integrated as a transversal topic into degree programmes throughout all levels of university education, with it embedded as a compulsory part of curricula. This means that, for example, all engineering students receive some risk education, and that it is not just an optional module or only part of a specialist OS&H and engineering degree…;*
3 *like all employers, universities have to run themselves safely and comply with OS&H legislation, requiring attention to be given to the health and safety of professors themselves and other staff. Addressing safety issues for staff and students can be used as a learning opportunity and such a holistic approach is strongly supported by OS&H-education experts…. An explicit emphasis on a safe and healthy university environment combined with OS&H education is probably the most effective way to instill OS&H awareness in students.*

Where the engineering sciences are considered, we can state that the professional engineer education is characterized by a Safety Culture laying at the very heart of the basic training: it would obviously be simply unconceivable a project –a typical engineers' task- disregarding the safety principia (e.g. static/stability) both during the realization phases and in terms of characteristics of the final result, the subsequent maintenance operations included.

This imposes a training devoted to an effective approach to the safety aspects, a really wide field, including, as a pivotal topic, the design and introduction of measures suitable to ensure the safety and health at first of workers at the production sites, secondly of the users and maintenance crews, and last but not least, the minimization of the impact on the areas surrounding the production activities.

4 AN EXAMPLE OF UNIVERSITY EDUCATION ON OS&H IN POLITECNICO DI TORINO

Politecnico di Torino is a research university and a leading institution to study engineering and architecture (basic information is summarized in Tables 2, 3, more detailed information available in website).

Table 2. Main aspects of teaching in Politecnico di Torino.

RANKING 2016 QS World University Ranking		
by Faculty: #66 Engineering and Technology		
EUROPE	by Subject	WORLD
#16 Architecture/Built Environment		#50 Architecture/Built Environment
#9 Civil & Structural Engineering		#37 Civil & Structural Engineering
#10 Electrical & Electronic Engineering		#40 Electrical & Electronic Engineering

Table 3. Main aspects of teaching in Politecnico di Torino.

TEACHING			
Students (A.Y. 2016/2017) 31500 students enrolled in Bachelor's and Master's degree programmes 14% international students 5300 first year students 360 students enrolled in I and II level Specializing Masters programmes, Lifelong Learning courses and training courses for businesses 700 PhD candidates		Graduates 2016 6533 graduates 3206 Bachelor's degree graduates—*Average age: 24* 3327 Master's degree graduates—*Average age: 26* Employment rate of Master's graduates one year after graduation 84.6% (Italian average 69.2%)	
Course catalogue (A.Y. 2016/2017) 22 Bachelor's degree programmes (3 in Architecture and 19 in Engineering) 30 Master's degree programmes (7 in Architecture and 23 in Engineering) 16 educational paths taught completely in English 1 I level Specializing Masters programme 9 II level Specializing Masters programmes 2 Interuniversity Specializing Masters programmes 7 Lifelong Learning courses 16 PhD programmes, including 5 in cooperation with other universities and research centers Quality & Commitment programme for Bachelor's students ASP for Master's students			
INTERNATIONALIZATION		Mobility students (A.Y. 2015/16)	
443 International agreements 453 Erasmus + EU PROGRAMME COUNTRIES agreements 118 Double Degree and student mobility agreements		791 Incoming students 1163 Outgoing students	
Human capital (figures update to 31/12/2016)			
Teaching staff		Administrative staff	
Full professors	209	Staff members	871
Associate professors	384	Female population	59.7%
Researchers	261		
Female population	27.4%		

With reference to the OS&H aspects, Politecnico di Torino provides some bachelor courses on OS&H basics, first of all to disseminate a proper terminology—on the basis of a Safety glossary drawn from international literature, up to Master Degree, Post-Graduated Master and PhD courses.

Post-Graduated Master and PhD courses in particular cover multidisciplinary aspects thanks to the cooperation with Occupational Medicine experts and Environment and Workplace Prevention Technicians from Università di Torino.

The results of the studies in cooperation with Public institutions such as the National Health Care system, the National Department of Labor, industries and construction companies, etc. are useful practical examples to enrich the frontal lessons.

Moreover, Politecnico di Torino has been encouraging and financing the special research program TGSIGTU—The General Safety Issues and Goals in Turin Universities, and deserves a special mention for the cultural and economic effort towards OS&H improvements, in terms of workers' safety and implementation of the aforesaid Education principia.

In the last 5 years, the Occupational success of both the Post-Graduate Master and PhD attendants ranged up to 85% employed in OS&H field within 1 year.

5 AN EXAMPLE OF UNIVERSITY EDUCATION ON OS&H IN POLITECNICO DI TORINO: THE OCCUPATIONAL RISK ASSESSMENT AND MANAGEMENT COURSE

The *Occupational Risk Assessment and Management Course* (12 academic formative credits, Master Degree, 2nd (final) year) provides to the student knowledge to deal, in a comprehensive and rigorous approach (risk should be expressed in numerical terms deriving from a solid statistical investigation, rather than using objectionable adjectives), with the problems of a thorough Hazard Identification, and deriving Risks Assessment and Management (Table 4).

The *Risk Assessment and Management* discussion is coherent with the modern principia considering OS&H as a part of a Total Quality system coherently with OSHAS 180001-2 standards.

The course structure divides in frontal lessons — discussing theory on the Occupational Safety and Health, i.e. Hazard Identification, Risk Assessment and Management—and examples drawn from real cases. The students will develop short thesis as team work, and solve some Problem Based Learning exercises (Problem Based Learning—originally conceived approximately in the 1980 (Barrows & Tamblyn)—is an alternative method of learning vs the

Table 4. The main topics of the course.

1. OS&H criticalities minimization on a probabilistic approach, and Risk Management techniques for normal and special activities (e.g. underground constructions, etc.). Situations where it is possible to simplify the approach in coherence with the statements of the EEC 5196/94 (GAH) document;
2. failures as causes of deviation from the design conditions critical for OS&H; availability and reliability, technical design and maintenance of systems and equipment;
3. discussion on statistical approaches on occupational accidents and health impairments adopted by Italian and foreign Agencies, and on the pivotal role of information on the standard violations associated to each accident for an effective Risk Assessment (where the data do not include such information, only the Attention Index becomes available, drawing the attention to the more common accident direct causes);
4. expert and computer assisted techniques for in depth and objective analyses of work related accidents, and their results for prevention;
5. basic elements of toxicology, Industrial Hygiene topics, concepts and techniques of the quantification (measurements representativeness included) of the concentration/level of pollutants at workplaces (chemical, physical, biological and carcinogenic pollutants possibly present in common and special working scenarios, such as tunneling in "green" rocks);
6. technical control design for pollutants at workplaces, workers' exposure assessment and reduction techniques, and emission/common environment pollution management.

traditional one, which stimulates the students to test their skills of management and organization within a working group, cooperating as a team to develop the skills of problem solving, under the constant supervision of tutors).

In particular, theory introduces the pivotal concepts of: Prevention through Design (NIOSH), System Quality approaches, and, obviously, up to date Italian, European and International Safety and Health Regulations and Standards.

Practice consists in Problem Based Learning exercises on case histories of critical situation occurred in some NACE sectors (mainly section-c: Manufacturing (metalworking industries), and Section-F construction activities (tunneling operations, linear yards and building construction sites).

The goal of the course is to make the students able to identify and use the most suitable Hazard Identification, Risk Assessment and Management techniques to face different scenarios.

The topics and their scheduling in terms of both time and discussion of theoretical aspects and practical developments, besides responding to the Dublin's descriptors, are in line with the Italian

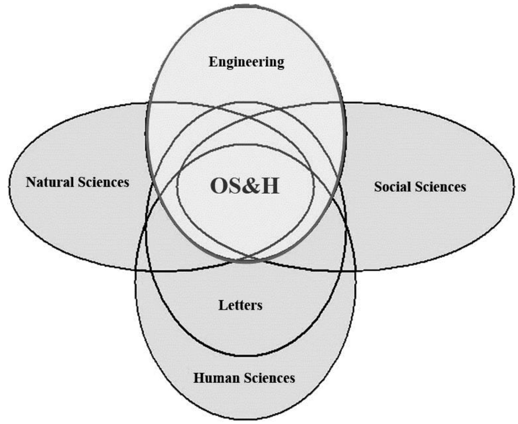

Figure 2. Multidisciplinarity of OS&H, modified from a Ceca—European coal and steel community—document of late '50: the concept was not born recently!.

official requirements (Italian Legislative Decree 81/08 – enforcement of the 92/57 EEC Directive-Annex XIV: minimum content of the 120 h training course for Coordinator for safety and health at the project preparation stage, and Coordinator at the project execution stage).

6 CONCLUSION

As discussed, a large part of the OS&H criticalities is due to serious cultural deficiencies of all the parties involved, from designers and managers along the whole Line and Staff Organization.

This confirms the essential role of a widespread dissemination of the Culture of Safety, to ensure an effective Prevention.

Education can play a pivotal role, and Universities, thanks to their nature of teaching and research institutions, can make the difference.

Among the various aspects of OS&H, where the multidisciplinary of approach is very important (Fig. 2), engineering can contribute from the very first steps of the feasibility and design phases in terms of Risk Analysis. Moreover, engineering research and development can implement innovative design, and quality and safety concepts for stakeholders, in particular at the launch of new projects of national and international interest.

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What role do OHS professionals play in the construction of industrial safety?

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ABSTRACT: A necessity for case studies describing daily operations in high-risks industries has been highlighted. Despite the central role of OHS practitioners managing safety constraints, little research on their activities has been carried out. This paper presents a long term in-depth case study conducted in a pharmaceutical chemistry plant. The objective of the study is to provide a description of the activities, roles and influence of OSH practitioners in order to identify how they contribute to the construction of safety within their organization. In order to address these issues the theoretical and methodological frameworks of ergonomics and sociology of organizations are used.

1 INTRODUCTION

1.1 *A framework for empirical studies in high-risk industries*

Some authors have emphasized the need to increase the knowledge of the day-to-day operations in high risk industries in order to improve safety management (Weick, et al., 1999; Bourrier, 2001). Thus, the multiplication of empirical studies is a key issue. Le Coze (2013) developed a model which aims to provide a framework for describing empirical realities and defining solutions for anticipating and preventing major accidents. This model called the "Systemic and Dynamic Sensitising Model of Safety" is derived from a critical analysis of well-established safety models such as the Reason's Swiss Cheese model, Rasmussen's hierarchical abstraction and migration models and Weick's collective mindfulness model. It adopts an interdisciplinary vision since it is designed to accommodate insights from diverse literatures on safety engineering, ergonomics, management, sociology and political science fields. The model suggests considering six dimensions as shown in the Figure 1 and commented as follows:

"(1) Strategy adaptations (by leaders) in the organization's environment (economical, political, social and technological) which lead to (2) A number of technological and organizational changes at different levels, which may positively or negatively affect (3) The design and/or implementation of (technical and procedural) safety barriers by those at the operational level (in teams and

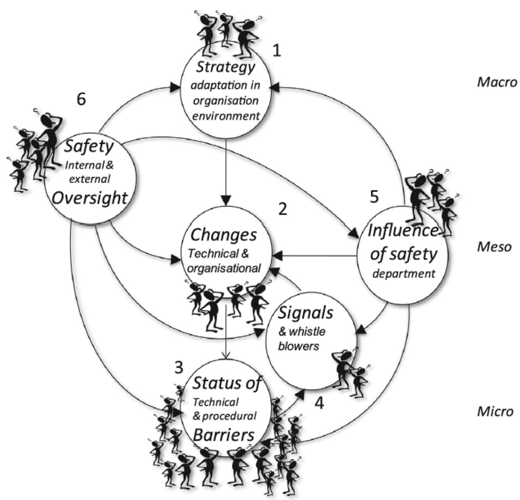

Figure 1. Systemic and dynamic sensitising model of safety (Le Coze, 2013).

departments), a situation monitored and controlled by (4) Firstly, an ability to process signals (possibly conveyed by 'whistle blowers') about specific safety-related problems or the negative impacts of changes to the design or implementation of (technical and procedural) safety barriers, relying on (5) Secondly, a safety department (or function) which can challenge the organization about the impacts of changes to the design and implementation of safety barriers and/or to the status of the processing of (weak or strong) signals. This department is backed up by (6) Thirdly, safety (external or internal) reviews which can play a role of 'organizational redundancy' for the internal safety department (or service) on these very same issues." (Le Coze, 2013, p. 213)

The study presented in this paper deals specifically with the 5th aspect, namely the influence of the safety department. Accident case studies such as explosions at the BP Texas City refinery (Hopkins, 2008), in a pyrotechnic company (Le Coze, 2010), or the Challenger shuttle explosion (Vaughan, 1996) highlight the need to draw attention to safety functions within companies. Those studies show the limits safety experts may encounter in participating in the safety or strategic decision-making processes. The lack of influence of experts may result from a geographical remoteness or power games that exclude them from key decision-making processes.

Despite the centrality of the safety function, the activity and the way OHS professionals contribute to the construction of safety has been poorly studied in itself.

1.2 *Literature on OHS professionals*

Several authors have highlighted a lack of knowledge about OHS professionals' work (Peissel Cottenaz & Garrigou, 2004; Brun & Loiselle, 2001; Harris et al., 2011). The literature states that it is necessary have a better understanding of this profession for two main reasons. Firstly, we observed that many studies were conducted in order to determine the possible positioning of OHS professionals and to envisage solutions to assist their impact in their organization (Dawson and al., 1984, DeJoy, 1993, Olsen, 2012). Our research study mainly supports this objective. Another purpose for some authors to carry out studies on this topic is to identify the skills that are required for novice OHS professionals and thereby improve training programs (Peissel-Cottenaz & Garrigou, 2004, Swuste & Arnoldy, 2003, Limborg, 1995).

Through an analysis of the literature, we identified two specific aspects that should be investigated further. On the one hand, research addresses the OHS profession mostly in terms of occupational health and safety issues but very little in terms of process safety. The first contribution of our research will be to describe the activity of the OHS professional in charge of process. Those safety issues are slightly different in the sense that occupational accidents, whether severe or minor, concern the task of an individual without necessarily implying hazardous processes such as a fall or a cut. On the other hand, process safety related accidents can affect the environment and a greater number of people inside or outside the plant. It concerns for example explosions or leaks of dangerous products.

Previous studies of OHS professionals are mainly based on questionnaire surveys (Brun & Loiselle 2001, Peissel-Cottenaz & Garrigou, 2004, Hale & Guldenmund, 2006) and, to a lesser extent, on interviews conducted in the context of case studies (Olsen, 2012, Daudigeos, 2013). Few studies were based on the observations of OHS professionals' real activities (Garrigou et al., 2003). According to Harris et al. (2011), qualitative studies should be conducted in order to grasp real activities and roles of OHS professionals and not only their perception of it. Our research is based on a case study in a high-risk chemical plant of a pharmaceutical company. The aim is to produce a description of OHS professionals' activities, roles, and influence in order to understand how they take part in the construction of industrial safety, on a daily basis. Those empirical results should round off the Systemic and Dynamic Sensitising Model of Safety.

1.3 *Articulation of ergonomics and sociological frameworks*

This paper raises two main research questions. It is suggested that ergonomic and sociological theoretical and methodological frameworks need to be articulated in order to deal with them.

Firstly, the daily activities of OHS professionals, especially those in charge of industrial safety, are poorly depicted. For this reason, our primary aim is to describe *what the work of an OHS professional in charge of industrial safety is about*. The implication of which is to conduct an ergonomical study of their activities. The real activity is analyzed by means of observations. The results describe characteristics of the work. They include vagueness in the instructions, the numerous and varied subjects to be treated, management of unexpected situations, interruptions of tasks, planning adaptations and numerous interlocutors.

The second research question we pose is *what roles do OHS professionals play and what do they entail in terms of power*? It is considered that understanding the activity of OHS professionals at a micro level is a prerequisite for understanding their positioning at the meso or macro level. Many specific situations are indicative of wider issues. However, ergonomics tools are not sufficient. David et al. (2000) express that ergonomics has difficulties in extricating itself from the particularisms of a situation. Using de Montmollin's words, "ergonomics is myopic". According to the authors, sociology allows to contextualize a singular situation in a broader system of social relations. Our study aims to describe the roles played by OHS professionals. The concept of role is interesting as it enables the understanding of individuals' behavior with regards to their characteristics and to the overall context.

We also attempt to show how roles are indicative of their power. To deal with the concept of power, we rely on the theoretical framework of the sociology of organizations developed by Crozier and Friedberg (1977). These authors explain that organizations are composed of a formal structure and modeled by power games between actors who are part of the organization. An organization always cope with constraints for which solutions are not obvious and involve uncertainty (Markets, product quality, availability, reliability and efficiency of processes, reputation, social climate, etc.). This concept of uncertainty is central to the strategic analysis. It refers to the turbulence that organizations must adapt to, and it is also considered as a resource for actors who control it. "What is uncertain from the point of view of problems is power from the point of view of actors". (Crozier & Freidberg, 1977, p24). Actors' abilities to keep their behavior unpredictable allows them to broaden their margins of freedom, and thus their potential for action.

Four types of "areas of uncertainty" that can be controlled by actors have been identified. From their empirical work, Crozier and Friedberg defined that the power depends on 1. The mastery of particular skills which are important for the organization; 2. Being a relay between the organization and its environment(s) (e.g. suppliers or customers); 3. Controlling communication and information within the organization; and 4. General formal and informal organizational rules. It corresponds to the role of the actor in the organizational chart, but informal rules may allow employees to protect themselves.

In this paper, we demonstrate the correspondence between the roles played by OHS professionals and the area of uncertainty they control.

2 METHODOLOGY

2.1 *A long term immersion*

The research is based on a single case study carried out within a French pharmaceutical chemistry plant. The plant employs 220 people and belongs to a group with an international scope. Six production teams are distributed into three units and conduct the installations 24 h/24. The first unit is in charge of synthesizing the molecule. The second runs the installation for the molecule purification. And the third unit is in charge of the effluent treatment. The plant meets the criteria of the European Union Seveso directive for classification as a high-risk site since chemicals involving major accident scenarios are stored and used in the production process. The safety department of the plant is composed of a safety unit manager, an industrial safety technician, an occupational health and safety technician, two environmental engineers and an assistant.

The particularity of the study is the long-term presence of the analyst in the research field. A total of 17 months was spent in the safety service as part of Ph.D. research. This include in particular four months dedicated to the understanding of the context of the operations, and one month to the observation of the activity of two OHS professionals. The two OHS professionals were the technician in charge of industrial safety and the safety department manager. The objective of this continuous presence was to maintain a strong link with the safety department as well as with other members of the company. It facilitated always being up-to-date on current events, being at ease with the language of the company, getting to know people, being invited to specific events and meetings, and discussing regularly with them about current missions, difficulties or feelings about work.

2.2 *Context analysis*

As mentioned previously, the first four months consisted of understanding the context of the plant. During this period, we conducted semi-directive exploratory interviews with 14 people: unit and department managers, project leaders and the director of the site. The aim was to have a global vision of the site organization and of the different activities carried out. Data collected concerned history of the site, role, and organization of units and departments, individuals' backgrounds and products manufactured. Then, we observed the activities of the operators working in the production units. The objective was to understand their different activities, to discover the processes and the production constraints. This represented 110 hours of observations during which we focused on different data such as daily activities, non-standard operations, process hazards, safety barriers, information flows, procedures, operator training, etc. Finally, we participated in different meetings and trainings involving the safety department in order to glean information about the site organization, the safety department assignments and on their relationship with other services.

2.3 *Activity analysis*

The activity of the safety department manager and of the technician in charge of industrial safety was analyzed through overall observations and systematic observations. Overall observations lasted two weeks (one week with each of them) which represents a total of 73 hours. It consisted of following and questioning actors when they carried out their different tasks. The purpose was to understand what their real activities were and to comprehend their interactions with others. For technical reasons, it was impossible to record verbal messages using electronic equipment. However, a detailed logbook was kept.

From those results, an analysis grid has been drafted in order to prepare systematic observations. The systematic observations were carried out over five days for each of the two OHS professionals, which represents approximately 81 hours of data collection. The "paper-pencil" method was used again. The data collected concerned: goals of the activity, identity of interlocutors, types of interactions (meeting, planned or unplanned interactions, formal or informal interactions), the content of interactions, communication medium (phone, e-mail, face-to-face communications, etc.). During the observations, OHS professionals were asked to explain what the task in progress was, the objectives to be achieved, difficulties encountered and sometimes their view about it.

3 CHARACTERISTICS OF OHS PROFESSIONALS ACTIVITIES, AN ERGONOMICAL ANALYSIS

3.1 *What is the work of an OHS professional in charge of process safety?*

The study conducted by Garrigou and al. (2003) is based on an analysis of the activity of OHS professionals and highlights various characteristics of this work. The authors indicate that this is what they call an "emergency management activity" because it is characterized by a multiplicity of heterogeneous situations, with different temporalities and that are managed in parallel. They also specify that interruptions are constant and planning adaptations are frequent. In addition, the activity of OHS professionals involves interactions with numerous internal and external actors. Several of these elements have also been highlighted through our study.

The characteristics of the OHS professionals' activity are described as follows: 1. Vagueness in the instructions; 2. Quantity and diversity of topics; 3. Unpredictability and fragmentation of the activity; and 4. The great diversity of interlocutors.

3.2 *Vagueness in the instructions*

First, in order to understand the activity of OHS professionals, it is necessary to know what they are assigned to do. However, the instructions seem unclear. Job descriptions only indicate broad orientations such as: *"Advises management on the definition and implementation of the environmental safety policy on the sites concerned"* or *"Coordinates, facilitates and ensures the implementation of this policy among operational staff"*. The safety department manager established a division of topic to be treated by each member in order to improve the definition of their activity scope. However, these instructions do not say how the work should be done i.e. what the tasks and the objectives are.

Discussions were held with each member to understand more precisely what their tasks are. What transpired is that the OHS professional's job is difficult to describe. They presented their activity in terms of themes such as types of risks (technological, natural) or regulations to be met (ICPE, under pressure equipment, ADR, etc.). They sometimes describe their task with presenting the objectives as "*ensuring regulatory compliance*", "*ensuring that everyone has the right training for the activity they are carrying out*", "*having as few accidents as possible*".

In summary, the tasks are unclear because they are numerous, varied and are not carried out in the same way from one time to the next according to the situation, i.e. the experience of the person in charge of it, the interlocutors, the budget, problems encountered, changes in regulation, time availability, etc.

We propose to see the instructions coming not only from the hierarchy, but also stemming from other sources. It may include, for instance, requests from public authorities, regulations to be respected, other colleagues from the safety department or from the plant, suppliers, subcontractors, and, sometimes, tasks are even defined by the OHS professional herself or himself. The necessity to intervene can also result from specific events such as hazards within the facilities. Therefore, the activity depends on the way OHS professionals integrate and apply the different requests and context elements.

3.3 *Quantity and diversity of topics*

According to the results of systematic observations, the safety department manager and the industrial safety technician have been requested respectively for about 190 and 100 topics in five days. The topics are issues for which OHS professional receive information about, but may or may not have to deal with. The topics related to industrial safety for which the safety department manager dealt with are for example the emergency response plan update, the work of installing an air extractor in an explosive atmosphere area, the best type of acid for a new product process, choice of safety device on new facilities, an incident relating to a discharge at a gas scrubber, etc.

The industrial safety technician dealt with the topics as risks related to the process for a new molecule production, a false alert alarm at the hydrogen storage, an incident related to the overflow of soda tank, non-standard operation on the cleaning of a pit, etc.

They also, sometimes, are in charge of subjects remote from safety such as, for instance, the holiday management, the loss of a maintenance standby phone or the visit of the plant by students. For OHS professionals, dealing with a topic involves tasks such as interacting with other actors, organizing meetings, sometimes seeking technical or regulatory information, monitoring operations or creating documents such as feedback reports, investment files, or non-standard procedures, etc.

3.4 *Unpredictability and fragmentation of the activity*

The activity of OHS professionals is characterized by unpredictability, in particular because of the many requests they receive.

The results of systematic observations show that the time devoted to unplanned exchanges, written or oral and formal or informal, accounted for 25% of the working time of the safety department manager while planned exchanges or meetings accounted for 62%.

Concerning the industrial safety technician, unplanned exchanges accounted for 33% of the working time and planned exchanges for 47%. Respectively, only 13% and 20% of the safety department manager's and the industrial safety technician's working time didn't imply any interactions.

Furthermore, they are frequently interrupted. The safety department manager and the industrial safety technician were each interrupted 4 to 13 times a day during a task in progress. Responding to interruptions (without processing the requests) represented on average 35 minutes of a working day, that is to say, 6.7% of the time for the safety department manager and 24 minutes, i.e. 5,7% of the industrial safety technician's working time. This causes a fragmentation of activity. They need to adapt to the multiplicity of requests and manage several subjects in parallel.

3.5 *A great diversity of interlocutors*

The diversity of OHS professionals' interlocutors is presented in table one. We classified them in 4 categories. The prefix "intra" and "inter" refers to whether the actors belong or not to the field of safety. The suffix intern and extern refer to whether the actors belong or not to the safety department.

Table 1. Diversity of interlocutors.

Intra-intern actors	Safety Department Assistant; Environmental Engineer; Occupational health and safety technician; Safety department manager
Intra-extern actors	Supervisory authorities; Safety managers from other plants of the company; Corporate risk managers; Chemical Industries Union members; HSC members; Inspection agencies
Inter-intern actors	Operatives; Technicians; Agent-control; Managers; Assistants
Inter-extern actors	Providers; Subcontractor; University

From our observations, we notice that the main interlocutors of the safety department manager are the other managers of the site. He is also frequently in touch with members of his team. He occasionally interacts with operatives, technicians and with actors outside the site such as corporate risk managers and supervisory authorities.

The industrial safety technician interacts especially with "actors in the field" such as technicians and operatives. However, he is also frequently in touch with the managers and members of the safety department.

4 ROLES AND INFLUENCE OF OHS PRACTIONERS, A SOCIOLOGICAL APPROACH

4.1 *OHS professionals' roles in the literature*

Several studies have attempted to define the roles played by OHS professionals in order to identify the link with their influence within their organization. However, there appears to be no consensus on the role that should be played. Indeed, some authors believe that OHS professionals must participate in strategic decisions in order to have a real impact (Swuste & Arnoldy, 2003). On the other hand, some authors argue that it is necessary to be positioned as an expert in order to leave the decision making to the management. This should avoid the situation that safety is only taken into account by OHS professionals (Dawson et al., 1984).

Hale (1995) has identified three main roles that can be played by OHS professionals according to their relationship with the management. These are the roles of expert, controller, and coordinator. According to our observations, we consider that these categories are relevant to apply. However, we suggest that OHS professionals don't play just one of these roles but can play all of them depending on the situation. In order to identify the link between the roles that are played by OHS professionals and the power they have in their organization, we use the sociology of organization theoretical framework developed by Crozier and Friedberg (1977).

4.2 *A role of expert (1st area of uncertainty)*

The role of expert that OHS professionals play corresponds to the first area of uncertainty i.e. the mastery of particular skills. The results obtained from the characteristic of their work demonstrate that they are called upon for a great diversity of subjects. The power they have depends, in part, on their ability to address the different issues, and on the dependence of other actors on their knowledge. Our study shows that they have two particular scopes of expertise: a technical and a regulatory one. The knowledge and skills they have to run the site safely are especially important for the company that highlights safety as its main concern. Furthermore, it is necessary to produce in accordance with the regulations as some audits are carried out by an inspection authority which can send formal notices.

The role of technical expert is endorsed during the activities of an investigation after an incident, process risk analysis, of solving technical problems, or for the management of technical contingencies. They are expected to understand the technical issues expressed by the other actors (maintenance, methods, manufacturing, etc.). For example, during incident investigation, OHS professionals must ask relevant questions to understand how the situation has occurred and to define a relevant action plan. Similarly, a process risk analysis requires working closely with facility specialists to define appropriate protective equipment.

They are also sometimes asked specific questions. As an example, during the observations, the safety department managers was asked to decide on an option concerning a facility design project. He had to specify if the reduction in the expected size of a blowhole involved new risks. He defined its requirements in relation to factors such as the temperature of the reaction medium, the boiling temperature and the temperature of the decomposition medium.

Additionally, it was necessary to take into account the constraints imposed by the public authorities through the application for an operating permit. OHS professionals also have a strong expertise related to the understanding of the regulations. The scope of regulations is vast and includes for example the Directive on the inland transport of dangerous goods, the Pressure Equipment Directive, regulation for establishments classified for environmental protection, etc. The industrial safety technician is in charge of keeping track of changes and of the conformity checks. Furthermore, he participated in the definition of a strategy for manufacturing a new product on the site. The objective was to avoid the thresholds being exceeded for different types of chemicals according to the ICPE sections.

4.3 *A role of coordinator (2nd and 3rd area of uncertainty)*

The description of OHS professionals' activity characteristics shows that they play an important role in coordinating information. Our systematic observations results indicate that the safety department manager and the industrial safety technician spent 87% and 80% of their working time interacting with other actors. It can be verbal (meetings, informal exchanges, telephone), or written exchanges (emails). They interact with many actors on the site and with external actors. This role of coordinator can be linked to the control of two zones of uncertainties described by Crozier and Friedberg (1977), that of being a relay between the organization and its environment(s) and controlling communication and information within the organization.

OHS professionals obtain information through the various meetings they attend. The safety department manager is a member of executive committees. He is aware of strategical orientations of the site such as organizational changes, or investment projects. Furthermore, OHS professionals attend daily meetings about performance indicators in order to be aware of the issues encountered on the site in all sectors. Another means for OHS professionals to obtain information is to be an active observer of activities on site. When they do have time, they visit production buildings and talk with employees about the current activities or situation. They share their information when they respond to the variety of requests for which they are asked.

Regarding the role of relay with the environment, the technician is in contact with external actors such as firefighters and suppliers or subcontractors to carry out works. The safety department manager has a particularly important positioning as a relay since he is the main interlocutor for supervisory authorities in the context of audits. Owing to its relationship with these actors the safety department manager knows the safety-related regulatory constraints in his own organization.

4.4 *A role of controller (4th area of uncertainty)*

The role of controller is related to the last area of uncertainty that we mentioned, that is to say, the general formal and informal organizational rules. To some extent, they have an influence on the activities of other actors through rules and procedures. They are the signatories of permits and work vouchers, they validate the derogation requests and define the operating procedures to be applied in the event of an exceptional situation. The head of the safety department also has power over the members of his department as a manager.

The role of controller can only be exercised through a certain expertise. For example, for the validation of derogation, the OHS professional must analyze the request coming from the manufacturing department. It indicates the problem and compensation measures that would allow the activity to continue in an acceptable security situation within a given timeframe. In order to make a decision, the SE manager relies on his technical expertise. He takes into account, in particular, the fact that there is redundant equipment and the dangerousness of products and reactions.

4.5 *Some barriers*

The definition of OHS professionals' roles highlights the areas of uncertainty that they might control and use to influence other actors' behaviors or decisions. Our study, based on activity analysis and long-term immersion also enabled us to identify several difficulties they face and that can diminish their power.

Some difficulties might result from the will of the other actors to maintain the control of their own areas of uncertainty. For instance, OHS practitioners sometimes meet difficulties in accessing all the information they need for answering a request. For example, they don't always get all the technical information they need for incident investigations or for process risk assessments. In addition, they feel that they do not have enough feedback on what happens on the site outside of daytime schedules. They do not always know how safety procedures and instructions are applied by teams that work in shifts.

They also often lack time to deal with substantive issues. The different demands received by prevention workers prevent them from taking time on subjects that are not urgent but nevertheless important and require a certain amount of time (for example regulatory watch or the updating of ATEX zoning). They may think that some of their tasks could be redistributed to other members of the company to focus on safety specific and fundamental topics.

In addition, they sometimes have difficulty in making others understand the scope of their responsibilities. Indeed, they are sometimes expected to answer to very technical issues, such as the optimum temperature threshold on a specific installation. On the contrary, they might not be invited to meetings where they could provide sound technical and regulatory data.

5 DISCUSSION

5.1 *Autonomy and margins of maneuver*

We noticed that OHS professionals have a significant autonomy to endorse the role they want to carry out during their activities. They play different roles, in part, according to their experience and values. For instance, we noticed that for the same task, which was to conduct a process risk analysis using the HAZOP method, the two OHS professionals didn't play the same role. The safety department manager is a process safety engineer and has been employed as a technician in the company for about 12 years. Therefore, he knows the plant processes very well. When he was in charge of risk analysis, he played a role of technical expert and was responsible for decision making. The industrial safety technician took over this task but perceived his role to be as a coordinator. He wants to be a facilitator and to rely on the whole group for making information available and for decision-making.

Roles are played autonomously since the instructions are not precise. This leads them to build their own positioning and the method for addressing responses to the requests they receive. However, in spite of a strong autonomy, we found that they have limited margins of maneuver to carry out activities. They are constrained by many external factors that can be indirectly linked to activities as a lack of financial or human resources, the organization of shifts, etc. The constraints can also be related to professional realities such as the number and diversity of topics, the urgency to treat them, interruption of tasks, availability of information, etc. Finally, margin of maneuver also depends on internal factors such as skills and knowledge.

5.2 *OHS professionals' skills*

This study highlights the diversity of skills required to carry out the work of OHS professionals. Access to information depends on relationships and the confidence they build with other actors within and out of the site. OHS professionals need to be able to listen to people and understand or question situations that they know little about. However, relational skills are not sufficient to adopt a position of controller or expert. It is also essential to have special expertise in order to be called-upon for advice by others. Expertise may include technical and regulatory aspects. Furthermore, the characteristics of the activity, involving fragmentation and constant adaptations of planning shows that it is also necessary to have adaptive qualities, to know how to manage several subjects in parallel and to be able to react quickly.

5.3 *Impact of OHS professionals on the construction of industrial safety*

The roles and influence analysis lead us to question the links with the dimensions that constitute industrial safety according to the SDSMS model. This model positions the different dimensions depending on the micro, meso or macro level. The results of our case study show that OHS professionals have an important role especially at a micro level and to some extent at a meso level.

OHS professionals endorse a role of controller regarding operational activities (i.e. dimension 3: status of technical and procedural barriers). In particular, they establish non-standard operations procedures, ensure the functioning of technical barriers and follow up and validate derogations requests.

The role they play for the fourth Dimension (Signals and signal blowers) is central. They are in charge of incident or accident investigations as experts of the feedback method. In addition, they manage the implementation of safety action plans. One challenge is to ensure that information about production activities is fed back to them.

Concerning the second dimension (technical and organizational changes), the safety department manager indicated that he is increasingly called-upon as a safety expert for new installation designs even if it is not systematical. However, safety department was not involved in organizational changes that were conducted on the site during our case study.

Concerning the sixth dimension (Safety internal and external oversight) the safety department manager plays an important role of relay. He is the interface with the control authorities for different subjects related to security, emergency plans, or hazardous equipment conformity. Within the company, he is the main facilitator during HSC meetings.

Finally, regarding strategical aspects of the company (dimension 1), some directions are in the process of being decided and will affect operations on site (change of installations, change of products used). These decisions are made by corporate headquarters and the safety department is not consulted.

This study thus examines the impact OHS professionals may have on the industrial safety level. The question of influence can then be expressed in terms of roles and scope of activities managed by the OHS professionals. Their presence on the ground as controller aims at ensuring that production activities are conducted safely. Additionally, it allows them to develop their expertise and to become legitimate experts. It is time-consuming and requires varied skills, and a strong adaptation to the quantity and diversity of the requests. Therefore, the possibility of having an influence at a macro level while managing the daily activities and their hazards is to be questioned.

6 CONCLUSION

The research introduced in this paper is based on a case study conducted at a high-risk pharmaceutical company. The aim is to provide a description of activities, roles, and influence of OHS professionals and to reflect on the means to analyze them. For this purpose, we suggest articulating theoretical and methodological frameworks of ergonomics and sociology of organizations. This articulation allows anchoring actors' activity in a relational system and to interpret their influence on it. The discussion sought to show how OHS professionals contribute to the construction of industrial safety within their organization through their activities, roles and through the areas of uncertainty they master.

The particularity of the study is the long time spent in immersion. This assisted the understanding of the context, the scope of the activities and the characteristics and subjectivity of actors. The main limit of the research is that a single case study was conducted which prevented us from making comparisons. Other case studies are needed to underpin the diversity of organizations and activities of OHS professionals in order to define the various forms of influence they can have.

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Education and training. Pre-requisite for safety

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ABSTRACT: This paper examines why there is a need to provide occupational safety and health education and training. The history of workplace health and safety education and training is traced through British legislation, the International Labour Organisation (ILO) and through Australian law. Case studies and examples of what is currently included in work related safety and health education for children, people in the workplace, for the public, and the benefits of this education, are included.

1 INTRODUCTION

With the many technological inventions used in industry there is an increasing need for employee work related education and training to be able to do the work safely. Many accidents occur when people are new to a workplace if education is not provided on how to work safely (Burt, 2015). The following is an example from Australia. As part of giving public service and helping the next generation to learn about working in industry a 15 year old college student was provided with work experience at Tho Services Limited. This student was given a visitors induction at the workplace. The work that the student was asked to do was welding, but he was not given any education or training on how to wear the supplied welding helmet or told about the need to pull down the eye protection visor to protect his eyes while he was welding, so he did the welding with no eye protection. This resulted in the work experience student receiving flash burns to his eyes and losing part of his vision permanently in both eyes (Supreme Court New South Wales, 2016; ABC, 2016).

The student now requires visual aids for the rest of his life, he cannot play football or cricket which he previously enjoyed doing as he now cannot see the ball, his future employment prospects are limited and his quality of life is decreased. The employing company was fined $240,000 by SafeWork New South Wales for breaching section 32/19(1) of the Work Health and Safety Act 2011. The company owners could not pay this amount so the company went into liquidation and all employees lost their job at this company (ABC, 2016; Supreme Court New South Wales, 2016).

This case study highlights some of the reasons that education and training are a pre-requisite for knowing how to work safely. In this case the lack of safety education for a work experience student affected a small number of people. A case where lack of training and education affected the safety of a larger number of people was the Bhopal Methyl Isocyanate (MIC) Pesticide Plant disaster in India on the night of the 2nd to the 3rd of December in 1984.

2 WHO NEEDS THE EDUCATION AND TRAINING?

The following story of the Bhopal disaster illustrates that everyone who is employed by the company at the workplace, and also people in government and the community, need education related to workplace safety.

In 1975 plant operators at the Union Carbide India Bhopal Methyl Isocyanate Plant had received an average of 18 months safety and work related education and training on how to operate the plant safely. Over the subsequent years the amount of work related education and training that the plant operators received had decreased to less than a month per person by November 1984 (Chouhan, 2005). In 1981, after the technical experts from the United States of America left this Union Carbide Plant because the plant was not making a profit, there was very little work related training and education provided for employees (Bowonder, 1987). In 1984 the remaining plant operators had been trained to use storage tanks that were later modified, but no training was provided to the plant employees on the use of the modified tanks (Weick, 2010). This highlights the need for ongoing employee education, particularly when there are work related changes. On the 3rd of December 1984 the work supervisor ordered the washing with water of the 4 lines to the MIC tank as the tank was not pressurising and the lines were blocked with rust and solid sodium salts (Chouhan, 2005).

The supervisor had only worked in the area for one month and had just been given the maintenance responsibilities. To save money the company had eliminated the position of maintenance supervisor (Weike, 2010). The workplace supervisor did not understand the plant operations, had not been told how the equipment at the plant operated or the correct way to do the equipment maintenance. The operator who was washing the lines was a new worker. He did not know that he needed to put a slip blind into the pipe so that the water would not go into the MIC storage tank and cause a chemical reaction (Bowonder, 1987; Weick, 2010). This highlights the need for work related safety education and training for new employee at a company and for employees who are new to an area of work.

When there was a build-up of pressure in the MIC tank due to an exothermic reaction with the water that entered the tank due to the line clearing workers could smell MIC in the air, but chose to ignore this as they did not know what to do (Weick, 2010). An hour later there was a massive explosion. The situation was made worse in that none of the fire and rescue squad members were trained or qualified to deal with this type of accident (Chouhan, 2005).

There was also lack of community safety education about the Bhopal Union Carbide plant and its products. The Government allowed the Union Carbide Bhopal plant to be placed in a residential area and for members of the general population to live in large settlements close to the plant when this plant was manufacturing MIC based pesticides as members of the government did not understand the dangers of this decision. The general population also did not know the dangers of living close to this major hazard facility (Bowonder, 1987). This highlights the need for education related to major hazard facilities to be provided to decision makers in government and to the general population.

Following the explosion at the Bhopal Union Carbide plant the company Medical Officer told the Director General of Police and the Mayor of Bhopal that the MIC gas was only a minor irritant and that there was no antidote (Bisarya & Puri, 2005). In contrast Professor Gehoawat, who was present in Bhopal at the time, knew that the gas was heavier than air and that he needed to stay inside his hotel room to avoid exposure to this gas. He told all of the hotel guests to '(1) shift to the top floor, (ii) to close all of the windows, (iii) to switch on the ceiling fans and exhaust fans, (iv) to breathe through wet napkins and (v) to wash eyes with water as frequently as possible' (Gehlawat, 2005, p. 261–262). Gehlawat knew that milk was an antidote to the gas as casein and other substances in milk absorbs toxic substances, minimise entry into the blood stream and minimise the effects on other body systems, so he asked the hotel manager to give milk to all of the hotel guests. He had studied the effects of chemicals for many years so knew what to do to assist with chemical injury mitigation (Gehlawat, 2005).

At a temperature of 200^{D} C (which the MIC did reach) it forms a gas that contains hydrogen cyanide (HCN). The Medical Officer did not know this. The antidote to HCN is sodium thiosulfate which was given to some of the exposed victims and saved their life (Broughton, 2005). A German toxicologist came to Bhopal with 50,000 injectable vials of sodium thiosulphate, but was asked by the Government to leave Bhopal and not to provide the antidote to gas exposed people (Bowonder, 1987). The above information, if provided by the Union Carbide Medical Officer to the authorities, could have saved the lives of many of the people who died and would have given authority to the government to allow the provision of the antidote to the people who required it.

The Bhopal plant workers knew to stay indoors and none of these workers died due to the effects of the gas from the explosion. However, as a result of this accident there was the immediate death of 3,787 people in the streets of Bhopal. Trees in the path of the gas lost all of their leaves and many animals died, particularly cattle. The problem of disposing of the dead human and animal bodies became an environmental health problem (Bisarya & Puri, 2005). A further 3,000 people died within a week (official government figures. Other estimations were that 30,000 people died within a week). The Indian Government has recorded that 47,787 people subsequently died as a result of their exposure to the toxic gas (81,574 government recorded deaths) and 558,125 people were injured with, in some cases, severe and disabling injuries (Delhi Science Forum, 1985; Broughton, 2005; Eckerman, 2005; Bhopal disaster, 2017; Gehlawat, 2005). In 2003 compensation was awarded by Union Carbide to 554,895 people who had permanent severe disabling injuries as a result of their gas exposure on the night of the plant explosion and to 15,310 families where a family member was killed by the gas but at least one other family member survived (Broughton, 2005).

The high number of deaths and permanent disabling injuries was, in part, due to insufficient employee education and work related training, to the lack of knowledge of the company medical officer, to lack of government knowledge about plant related safety, and due to lack of knowledge by the general population of the effects of the products manufactured at the Union Carbide Plant in Bhopal.

This disaster shows that for people to know how to work safely and to understand the dangers in a workplace there should be relevant education for everyone who has decision making and that employees and their supervisors need to be trained in how to perform their work correctly and safely.

Oxford Dictionaries (2017, p.1) define education as 'the process of receiving or giving systematic instruction'. Business Dictionary (2017, p. 1) record that training is an 'organized activity aimed at imparting information and/or instructions to improve the recipient's performance or to help him or her attain a required level of knowledge or skill.' Much of the work related education may be provided through educational institutions, such as the formal degree qualification for a medical practitioner, while the training would be more likely to be provided by people at the workplace, such as instructions by a supervisor to an employee on how to put a slip ring into a pipe and an explanation of why this is required to have a safe work process.

3 HISTORY OF WORK RELATED EDUCATION AND TRAINING

In the early years (before the industrial revolution) parents and tribe members provided training to their children on how to hunt, gather and later to do farm and other work so that the children did not get sick, injured or killed while working. The most common education and training method used was buddying up an inexperienced worker with an experienced worker so that the experienced person could explain how to do tasks to the learner. In this situation there was individual training and the education provided depended on the knowledge level of the trainer.

Then came the industrial revolution with machinery that could be dangerous to operate, the use of chemicals and other substances that could harm human health, more complicated work processes and the employment of people (employees) for long hours for wages. These workers were employed to make money for factory owners. Many factory owners were just interested in producing products for profit and did not consider their employees work related safety and health. Employees were just part of the production process. Employee collective power was weak at the beginning of the industrial revolution as most employees just wanted to have a wage to be able to support their family. Factory owners provided very little employee work related education.

Working conditions in the 1700 s were difficult and often unhealthy in Britain. The first introduced safety and health legislation related to stopping very young children from working. This legislation was the 1788 Chimney Sweepers Act that was based on Dr Percival Potts's 1775 cancer research. Boys as young as four were being used as chimney sweeps. The chimneys were usually 9 by 9 inches wide so a small person was required to clean them. This Act stated that no boy should be bound as an apprentice before he was eight years old. His parents' consent must be obtained for the child to be employed as a chimney sweep, the master sweep must promise to provide suitable clothing and living conditions, as well as an opportunity to attend church on Sundays (Humphries, 2012).

In 1882 morals was in the title of the Health and Morals of Apprentice Act introduced by Sir Robert Peel because, once a month, the apprentices were required to attend a religious service to receive moral education. Apprentices were to be prepared for confirmation in the Church of England and must be examined on their religious knowledge by a clergyman at least once a year. Male and female apprentices were to sleep separately and not more than two per bed. Apart from when they attended church and were working in the mill children were locked into their upstairs (above the mill) accommodation. Child apprentices were from poor families and were bound and unpaid until they turned 21 years old. Most of the children working in the mills were between 5 and 8 years old and worked 13 or more hours a day. The local magistrates had to appoint two inspectors known as visitors to ensure that factories and mills were complying with this Act. One inspector was to be a clergyman and the other a Justice of the Peace. These were the 1st workplace inspectors and were unpaid. Very little work related education or training was provided to employees in the 1800 s in Britain. Under this Act there was more focus on religious education than work related education and many children died from work related causes (Morrish, 2013).

In Germany in 1871 Chancellor Otto von Bismarck introduced the Employers' Liability Law. At this time in Britain workers were covered by Common Law. Under common law if a worker could be found in any way responsible (contributory negligence) for a work related injury, such as the employee slipped on a workplace floor and broke his or her arm, then it was the employee's fault and no compensation could be claimed by the employee. There was a culture of blaming the victim for their work related injury, ill health or death. If the injury resulted in part from any action, or inaction, of a fellow employee then, under the fellow servant rule the employer was not responsible. To ensure that the employer had no responsibility for any work related injury or ill health when an employee signed a contract of employment then the assumption of risks of harm from doing the work was formalised in many workplaces with the employee abdicating all rights to sue to obtain payment for any work related injury or illness. This was 'known as the "worker's right to die," or "death contracts"' (Guyton, 1999, p. 106).

Following the introduction of the Employers' Liability Law in Germany in 1880 the British Parliament passed the Employers' Liability Act. This was the first British legislation in which employers would be required to pay workers' compensation if the accident was caused by the negligence of a manager. It also abolished the 'assumption of risk' that employees previously took when they accepted employment. As there was now a financial consequence for work related injuries that could be traced back to employer management of the work, employers began to provide employee work related training. However accidents were considered by many employers as the results of poorly motivated employees not paying attention to what they were doing. Safety education was a matter of telling people to be more alert (History of occupational safety and health, 2017).

In the United States of America many employees were injured, died or developed black lung disease (pneumonconiosis) when working in the coal mining industry. In an effort to improve coal mine safety in 1864 the Pennsylvania Mine Safety Act was brought into law. This was the first workplace safety law in the United States of America and, to cover employers against paying for employee work related injuries, ill-health or a work related death at the same time the first insurance policy was issued in the United States of America. However it was not until 1970 when President Nixon signed into law the Occupational Safety & Health Act that legislation in the United States of America required employers to provide employees with education and training to safely do their work (Braithwaite, 1985).

In Australia 1800 to 1911 was the era of social legislation in which Australia had its first occupational safety, health, welfare and workers' compensation laws passed and enforced by the government. 1911 to 1959 was the inspection era in which safety inspectors targeted checking guarding, housekeeping and physical conditions. Before the 1970 s occupational safety and health legislation in Australia was prescriptive, detailed and hazard specific. Safety was seen as the responsibility of government inspectors. Safety Performance was measured by disabling injuries and employees were not required to have occupational safety education.

In Britain, in 1972, Lord Robens submitted a report on occupational safety and health legislation with recommendations to change from having specific requirements to having a general duty of care which applied to everyone who could affect, or be affected by, workplace safety, including the employer, employees, manufacturers, installers, suppliers of goods and services, to ensure that the workplace, work processes, goods and services were safe and healthy for everyone who came on to the workplace, conducted work processes, and/or who could be affected by the work, goods or services provided (Brooks, 1987; Ochsner and Greenberg, 1998; Adams et al. 1999; Milgate et al. 2002).

As well as the Robens report findings being the foundation of new British occupational safety and health legislation these findings were taken by the International Labour Organisation (ILO) and were published as ILO Convention 155, Occupational safety and health and the working environment. This Convention was ratified by many countries. When an ILO Convention is ratified by a country's government it forms the foundation of the country's law related to what was ratified. One of the countries who ratified ILO Convention 155 was Australia, so the Robens philosophy was incorporated into Australian occupational safety and health law.

As part of the Robens philosophy, which became law in Australia, employers had a responsibility to 'provide such information, instruction, training and supervision of the employees as is necessary to enable them to perform their work in such a manner that they are not exposed to hazards' [Occupational Safety and Health Act, Western Australia 1981, s19(b)]. To meet these requirements the employer had to provide all employees with instruction, training and work related education related to being able to complete their work safely. To check if this was actually happening in industry in 2017 the author asked people who were working in industry if they had received this work related education. Following are two replies.

> *"As for my call centre experiences regarding health and safety education all I can say is that the safety person always comes in during the induction, tells you that his door is always open but you quickly learn when you hit the floor that if you want to learn anything about your workplace safety or health or have any complaints and you raise them with your supervisor (who is on a temporary contract also) they won't raise them as they are worried about their job and if you raise any issues or ask for work related safety education then you will find your contract not being renewed at the end of the 3 month period. I guess the main point I was trying to make is that in this society we have such an enriched outsourcing environment where everyone is so worried about their job that they do not spend any time, apart from one orientation lecture, on safety education, employees are afraid to bring up safety issues and these sort of companies prime focus is on making money; not its employees safety education and well-being."*

In this case, although there is a requirement for education and training, the employee feels that, apart from in an orientation lecture, the legal requirements are not being met. In general, in Australia, if an industry is perceived as not being dangerous employees would receive a safety induction and an emergency procedures presentation. In industries where there are more perceived hazards safety education may be given on a daily basis. The following survey reply is related to one such industry.

"In Western Australia mining used to be one of the most unsafe industries, but this has changed dramatically and it is now one of the safest industries in the world."

4 THE WESTERN AUSTRALIAN MINING INDUSTRY

The path for the Western Australian mining industry to being one of the safest industries goes back, in part, to the implementation of the Robens Report recommendations into workplace safety and health legislation. In the United Kingdom (UK) in the Coal Mine Regulation Act 1872, there was a provision for mine workers to be involved in inspecting the mine in which they were working to ensure that it was safe. These employees were called Check Inspectors. Lord Robens saw how effective these Check Inspectors were in improving workplace safety and health so he included in his report employee involvement in workplace safety and health.

After the Australian Government ratified the ILO Convention 155 Western Australian mining industry safety and health representatives came into existence in 1995 with the implementation of the Mine Safety Inspection Act 1994. Safety and Health Representatives were employees who were elected by their peers to represent people in their work area on workplace safety and health matters.

Under this law safety and health representatives are legally required to attend a 5 day course to learn how to identify, assess and apply risk management processes to workplace hazards; how to conduct workplace inspections and investigations, apply health & safety legislation, communicate information on safety and health matters in their workplace, how to resolve conflict and issue Provisional Improvement Notices. Safety and Health Representatives are also encouraged to continue to attend other courses to update and improve their occupational safety and health knowledge. The knowledge that these employees gain through this education is then used to improve workplace safety and health.

In Western Australia, under the Mine Safety and Inspection Act 1994 and under the and Geothermal Energy Safety Levies Act 2001 a levy is collected from the mining companies and from major hazard facility companies to pay for costs associated with administering and enforcing safety laws. In 2015–2016 the levy collected was $25,160,000. The mining inspectors, as well ensuring legislation compliance engage with managers and other mining industry employees to provide education related to improving company risk management (Department of Mines and Petroleum, 2016a).

To be a Western Australian mining inspector the employment requirements are to have a Bachelor of Science or other approved Bachelor degree in an occupational health and safety discipline relevant to the resources industry. Qualifications or training in occupational hygiene, noise, environmental health, radiation, ventilation qualification or training in risk management or a related discipline are considered favourably. Demonstrated knowledge and experience of the practical application of occupational safety and health legislation and risk management principles within the resources sector is essential. Experience and skills in investigations managing emerging issues, changes and projects is required. Demonstrated ability to listen, understand and adapt to communication style and message to suit a range of audiences including the ability to negotiate effectively and convey information and structures via written and oral communication is important. Once employed there is also ongoing safety education for Inspectors to keep them up to date with work related knowledge.

As a summary these inspectors need to have completed formal tertiary education qualifications to have the knowledge to do their work, but they need more than this. They also are required to have good communication skills to enable the people who work in the Western Australian mining industry to learn from their expert safety knowledge. One of the outcomes of the work of the inspectors in sharing their work related safety knowledge is an improvement in the safety practices in the Western Australian mining industry. In Western Australia, in 1900, there were 45 fatal accidents reported. This was a fatality rate of 20% (Gilroy & Jansz, 2014). In the year 2012 there were no fatalities in the Western Australian mining industry (Jansz, 2012). In 2015–2016 there were four fatal accidents from an average work force of 102,343 workers. This is a fatality rate of 0.0039%. While this fatality rate is low the aim is always to have no fatalities as was the case with the Western Australian mining industry exploration workers (2,223 workers with no fatalities) in 2015–2016 (Department of Mines and Petroleum, 2016b).

Managers and many other employees who work in the Western Australian mining industry have formal work related education and qualifications. Other education provided is generic occupational safety and health education related to the Western Australian mining industry. Workplace health and safety orientation education can take between one to five days, depending on the company and the work that the employee will do. To keep up to date with occupational safety and health there are workplace Tool Box Talks that are often presented by the mining industry safety and health representative, by other employees, or by safety profesionals. At the start of a work shift in the mining industry there are Safety Shares in which employees share with the rest of their work team any safety related matters from the previous day, and lessons to be learnt (positive or negative) are discussed This is followed by talking about the safety factors that are important for the work in the shift that the employees will commence. Finally there are Safety Stops, usually when employees need to be trained in important safety matters by their supervisor. All of this education has contributed to making the Western Australian mining industry one of the safest industries to work in.

5 WORKPLACE SAFETY EDUCATION

The first accident prevention model was developed by Herbert William Heinrich who was born in America 1886 and died on the 22 of June in 1962 at the age of 76. Heinrich was an Assistant Superintendent at the Engineering and Inspection Division of the Travellers' Insurance Company when he published his first book called Industrial Accident Prevention: a scientific approach, in 1931. In the 1920 s when Heinrich conducted the research on the insurance forms the employers blamed the workers' actions for causing accidents. This was similar to the blame the victim culture in Britain at this time. The five dominos in Heinrich's theory of accident causation were (1) Social environment and ancestry. (2) Fault of the person. (3) Unsafe conditions and/or unsafe act. (4) Accident. (5) Injury (Hudson, 2014; Javaid, et al., 2016). This model was important as it formalised the need to prevent accidents from occurring by removing step 3, which were the unsafe conditions and act that occurred in the workplace to cause the accident that resulted in injury (Heinrich, 1931). To assist with the prevention of unsafe acts this model highlighted the need for employee safety education.

An American company that developed formal workplace employee safety education in 1930 s, following the publication of Heinrich's accident sequence model, was the Bell telephone company. This company trained its employees on safe work methods on the job and in the classroom. It displayed safety posters on the workplace walls to remind workers to work safely and had printed work procedure instructions. There was learning from workplace incidents and the workplace incident and accident report produced each month was shared and discussed with employees so that they could learn about the causes of accidents and how to prevent them from occurring. This company did more than just have employee education as, to improve work related safety, it included putting safety in the design stage of workplace tools, testing equipment for safety and purchasing equipment that was safe to use (Bell Telephone Company, 1949). In the 1930 s this was considered best practice in workplace safety.

In 2000 research was conducted to identify the aspects of organisational management that produce the best business outcomes in health care organisations. The findings of this research identified that what was most important was for the organisation to have a mission and a culture of care for everyone who came on to the business premises (Jansz, 2014). This is the same as the conclusion that the Robens report came to and resulted in a general duty of care being included in workplace safety and health legislation. Part of the model developed from the health care industry research included management providing and facilitating employee education and training, and employees being educated and trained in work related tasks. This resulted in minimal employee occupational injuries and sick leave. For private hospitals there was an increase in the number of customers due to a high standard of care being provided and the research identified that this made private hospitals more profitable. For government hospitals there was a decrease in the number of customers due to employees knowing how to work safely and giving correct patient care. Having less customers in government hospitals meant that less of the general population's tax money had to be used to support government provided health care (Jansz, 2014). When employees have work related education they are not only able to work more safely but are also able to work more efficiently and effectively. In contrast to this when employees do not have effective work related education and training major accidents can occur. An example of this is the Longford gas plant accident that occurred in Victoria, Australia.

At the Gas Plant at Longford in 1998 operators worked a 12 hour shift and during that time had to deal with 8,500 alarms so often worked in alarm mode. Through missing an alarm an operator allowed the plant to continue production with the condensate liquid above 100%. This caused the warm oil pumps to shut down. It took several hours for these pumps to be started during which time the metal heat exchanger became very cold (–50 degrees C). When the warm oil was introduced there was brittle metal fracture and the gas explosion that killed 2 men, injured 8 other people and cut off Melbourne's gas supply for 2 weeks.

Part of the cause of the accident at Longford was that the Engineers, who knew about "brittle metal fracture", had been relocated from the Longford plant to the head office in Melbourne. The Royal Commission, which was held to investigate this accident, found that the control room operator was not to blame for this accident as neither he, nor anyone else at this workplace, understood what caused brittle metal fracture. When hundreds of litres of fluid began flowing on the ground the operators thought that the bolts just needed tightening. Maintenance men were called to re-tension the bolts, but they found that no adjustment was required.

ESSO insisted that they had trained the employees about aspects of operating the gas plant. When tested on-line about what they had learnt some of the employees had ticked the right answer without understanding what their answer meant. For example, an employee had ticked "thermal stress" as a correct answer because that is what the book said was the correct answer. When questioned in the Commission investigation, this employee said he had no idea what "thermal stress" meant. Not understanding what thermal stress was contributed to the employees' decision to re-introduce warn oil into cold pipes which was a cause of the pipes rupturing.

Following this accident the court ordered penalty that ESSO paid for failure to adequately train employees and to adequately train supervisors was $(A) 2,000,000 (Hopkins, 2002).

As an outcome of this accident, and many other work related accidents, it became clear that employees must be education on hazard identification for the hazards or actions in their workplace that can cause harm, be trained in risk assessment, risk control and how to use the hierarchy of risk control measures. If an employee cannot implement risk control measures then they need to be trained to report the hazards that they identify to their immediate supervisor, or to the person who can provide the risk control measures required to make the workplace and work processes safe. As illustrated by the Bhopal case there is a need for the general public to also be provided with safety education.

6 PUBLIC SAFETY EDUCATION

In Australia most of the safety education provided to the general public is related to road safety. This education is provided through the media, through fines and through car drivers loosing demerit points for driving over the speed limit or having unsafe actions when in a car. In Western Australia once the driver has 12 demerit points their licence to drive is lost for three months. There are no rewards for driving a vehicle well, except that the person can remain licenced to drive.

According to the Safe Work Australia (2016) publication on Australian work-related traumatic injury fatalities from the year 2003 to 2015, two thirds (2,081 out of 3207) of work related traumatic fatalities involved vehicle collisions while the employee was performing work duties, most often on a public road, and 60% (803) of bystander (member of the public) work related fatalities were due to a vehicle collision while an employee was working, or the member of the public was hit by a work vehicle. In Australia the work related road transport fatality rate between 2003 and 2015 was eight times higher than the combined fatality rate of all other industry causes (Safe Work Australia, 2016). In 2015, 115 of the 196 work related fatalities involved a vehicle. It was also noted that 187 (96%) of the work related fatalities in 2015 were male (Safe Work Australia, 2016).

For children in Western Australia there have been a series of videos that have been shown on TV to promote children to think of safety before they act. WorkSafe Western Australia has 'Planet ThinkSafe' as an online educational resource for primary school children. It provides information to help children develop a positive attitude towards, and the skills to be, safe at school, home and in the community. It is part of the educational curriculum in primary schools and has cross-curricular courses and activities that have been organised into three levels; for lower, middle and for upper primary school children.

The WorkSafe SmartMove website is a comprehensive occupational safety and health educational resource for senior high school students and for new young workers that are entering the workforce on a work placement, work experience, or as a school-based trainee/apprentice. Features of the SmartMove website include having a SmartMove Certificate program containing one general and fifteen industry modules. High school students must pass and obtain this Certificate before being allowed to do industry work experience. The SmartMove Safety Passport program contains eight progressive online lessons that include videos, online learning activities, printable worksheets and a resource section that contains information sessions on current occupational safety and health topics. This program also has mapping documents and assessment tools for the national competency unit BSBWHS201 A, over seventy printable occupational safety and health lesson plans and worksheets that provide over 100 hours of activities for educators.

In Western Australia it is considered that all children need to know the principles of safety and health before they enter the workplace, have an understanding of how to identify work related hazards, assess the risk, report this risk to their supervisor and refuse to do any work that they do not consider safe for them to do.

7 IS EDUCATION AND TRAINING ALONE ENOUGH?

It is a start, but there are other factors to consider as is shown in the case of an employee at a Hay Baling business in Narrogin, who worked as a fork lift and press operator. This employee had been trained to drive a fork lift safely and had a High Risk Work Licence to operate a fork lift. Part of the training and competency assessment included not driving with the forks raised more than 30 centimetres. Following his training this employee had been warned on at least two occasions by his workplace supervisor not to drive with his forks raised.

On 22nd October the employee had loaded hay bales onto a feed table, reversed away from the table and set off in a forward direction with his forks raised at 1.7 meters high. This caused his view to be obstructed and he hit the driver, seated in another fork lift, with the fork prongs piercing the victim's torso and killing him. The employee was fined \$(A)11,000 and had to pay \$1,745 in court costs (Department of Commerce—WorkSafe, 2017). In this case the employee had been trained to work safely, had been told by his workplace supervisor to work safely, but did not and, as a consequence, accidently killed a fellow employee.

Another case where an employee had been trained to work safely happened in Queensland at the construction site for the ROMA liquefied Natural Gas project when Mr Glenn Newport died at work due to having a cardiac arrest brought on by dilutional hyponatraemia due to heat stress. How to work safely in the heat was discussed at the prestart meeting and strategies to work safely in the heat discussed and implemented prior to Glenn commencing his work for the day. There were workplace policies and procedures that employees had been trained to use to work safely in a hot work environment (Office of the State Coroner, 2016). Despite all of the education and training Glenn, who was 38 years old, was still affected by the heat at his workplace and died.

Similarly, Adam Perttula, a Jumbo machine offsider, was working in a hot, humid underground gold mine in Western Australia when he collapsed due to heat stress and died. Resources Safety (2015) Report No. 232 provided an industry alert on preventative action to be taken using the hierarch of risk control measures to prevent further work related deaths due to the same or similar causes. The Resources Safety recommendations for working safely were as follows.

1. Elimination. So far as is practicable do not have employees working in the heat.
2. Isolation. Isolate heat sources through shielding, containment or using remote control machinery to perform the work where practical.
3. Engineering controls, such as providing adequate ventilation to achieve a healthy atmosphere and reduce the heat experienced by employees.
4. Administrative controls. Use safe work practices such as job rotation.
5. Education. Provide training to employees on risk assessment and risk control measures to be taken to avoid any harmful effects from heat.
6. Monitor effectiveness of risk control measures used.
7. Personal Protective equipment. This is last on the hierarchy of risk control measures and personal protective equipment to protect from the heat is used if the other measures used are not adequate (Resources Safety, 2015).

In this hierarch of risk control measures it is noted that education and training comes after hazard elimination, isolation, engineering controls and administrative controls. As well as using the hierarchy of risk control measures Resources Safety (2015) provides information about the role of managers, supervisors and employees in preventing the heat related death of an employee.

The role of managers and supervisors include firstly to ensure all workers are trained to recognise the symptoms of heat stress (Resources Safety, 2015). Then the supervisor should provide detailed safe work practices that identify the hazards and controls for working in hot and humid conditions and ensure that the risk control measures are implemented. 'If the wet bulb temperature exceeds 25°C, an air velocity of not less than 0.5 metres per second must be provided for underground workplaces or in a tunnel under a surge stockpile. Supervisors must also arrange urgent medical treatment for anyone suspected of suffering a heat-related illness' (Resources Safety, 2015, p. 2).

All employees who have to work in a hot climate must understand the risks and symptoms of heat stress, and report any signs of heat stress to their supervisor. Employees also have the responsibility to ensure that they drink appropriate quantities of water to remain hydrated (Resources Safety, 2015).

Using this case study it is clear that it is the workplace management and supervisor's responsibility to ensure that employees have the education and training to be able to work safety and that the employee has the duty to make sure that they understand how to work safely so that they do not harm their own health or the safety and health of others. However education, while very important, is not the only answer. Where hazards exist the hierarch of risk control measures should also be used to make the workplace, work processes and actions of people as safe as is reasonably practicable.

8 CONCLUSIONS

Benefits of having education and training to enable employees to have the knowledge to work safely include minimising the number of employee workplace accidents, injuries and work related ill-health and maximising employee productivity due to the fact that employees know how to perform their work correctly and safely (Jansz, 2014). Other benefits are reduced legal costs, improved employee work related satisfaction, employee retention, reducing the cost associated with having to recruit and train new employees, reduced employee sick leave and lost work hours, reduced workers' compensation costs, the employer ensuring that they are meeting their legal obligations and responsibility for their employees (Australian Government, 2017).

The findings of this paper are that work related education and training are a pre-requisite for safety because, as was shown in the Longford Gas Plant disaster, in the Bhopal Union Carbide disaster, and in numerous other accidents, if employees do not have the education and are not trained in how to do their work safety major disasters can occur.

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Bridging the divide—OHS and process safety

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ABSTRACT: The occupational health and safety field is well established, with a number of professional bodies, undergraduate programs and a comprehensive body of knowledge. Conversely, the process safety field has evolved largely over the past 40 years as an engineering discipline, with a focus on engineering solutions. Both of these fields utilise a risk management basis for decisions and actions. But both fields still largely operate independently of each other. There is much to be learned from sharing knowledge and responsible collaboration to deliver safer plants and operations from an OHS and a process safety perspective. The IChemE Safety Centre established a cross discipline team collaborating with the OHS professionals from the Safety Institute of Australia to develop process safety content for the Occupational Health and Safety Body of Knowledge. This paper will explore this work and how it can be used to bridge the divide between OHS and process safety to achieve better safety outcomes. This includes better education and information flow between OHS and process safety professionals as well as leveraging off existing OHS systems to advance process safety. This should result in better safety outcomes for all.

Keywords: process safety; OHS; commitment

1 INTRODUCTION

There are many different fields of practice in safety. The most prevalent is the Occupational Health and Safety (OHS) generalist. The OHS Body of Knowledge (Pryor, 2012) defines the OHS generalist as a role that applies "a multidisciplinary body of knowledge in a unique way to provide enterprises with advice on the organisational arrangements that will lead to the systemic and systematic management of OHS to prevent work-related fatality, injury, disease and ill health." There are then many specialists that support these people, such as occupational hygienists, occupational ergonomists and occupational medical professionals to name a few. Traditionally process safety specialist have developed in the engineering field and have therefore remained separated from traditional OHS. This separation has resulted in the disciplines developing separately, and in some instances produced negative safety outcomes.

In an effort to bring the disciplines together the IChemE Safety Centre collaborated with the Safety Institute of Australia to develop process safety content for the Occupational Health and Safety Body of Knowledge. This content was written by a multi discipline team and published on line on 26 April 2017.

2 THE HISTORY OF OHS DEVELOPMENT

The development of OHS as a profession is closely linked to the development of safety related legislation. In 1802, the United Kingdom introduced the Health and Morals of Apprentices Act. This was the first step in managing child labour and working hours. In 1833 the Factories Act allowed for the appointment of inspectors to monitor factories and their workers. The legislative development continued in other nations, with legislation being introduced for coal mines in New South Wales in Australia in 1854, and a factory legislation in Victoria in 1873 (Pryor, 2012). In the United States the Safety Appliance Act was enacted in 1893, focusing on train safety. The industrial revolution introduced hazards not previously seen in society or the workplace. To manage these hazards, the various acts started to establish what was acceptable in society for worker safety. This then started the development of the OHS profession, as a means to address the expectations.

These developments largely focused on the individual hazard to the worker, such as entanglement, burn and amputation, as well as illness caused by exposures. Initially guarding was used to protect the workers, and in 1937 there was a move to start to focus on training and supervision of employees as a means to prevent incidents (Sankey, 1937). Following on from this there was a focus on injury treatment and then the focus shifted to industrial psychology looking at ideas such as accident-proneness (Pryor, 2012).

This evolution through engineered solutions to procedures and compliance followed by psychology has driven OHS forward. In more recent times we have seen the development for formal risk assessment frameworks and the introduction of duties on persons in the legislation. The latest developments in OHS are challenging the existing paradigm, and suggesting that there is a different way to look at safety. This new paradigm defines previous safety as 'Safety I' and the new paradigm as 'Safety II'. (Hollnagel, 2015).

While the merits of each phase can be debated, it is clear that they have contributed to where OHS is today. This field is well established and recognised.

3 THE HISTORY OF PROCESS SAFETY DEVELOPMENT

The origins of process safety concepts can be dated back to the early 1800 s with E.I. duPont's black powder factories being constructed with separation distances and blast zones, though modern process safety is said to have been established in the 1960 s. This is because in the 1960 s we started to see more, larger scale facilities being constructed, resulting in the potential for greater consequences. Improvements in process safety were driven by learnings from major incidents.

The 1974 Flixborough incident introduces management of change and blast proof control building. The 1976 Seveso incident expanded hazard identification and risk assessment as well as leading to the goal base Seveso directives. Bhopal in 1984 highlighted the need to consider inherently safer design principles. Piper Alpha in 1988 raised awareness of permit to work systems and lead to goal based offshore regulation in the North Sea. Further understanding of management of change, particularly organisational change as well as alarm management came out of the Longford incident in 1998. The Texas City refinery explosion in 2005 further highlighted building safety as well as understanding process safety and lead metrics. In 2009 and 2010 the Montara and Macondo incidents highlighted the need for better regulatory oversight as well as identifying issues in decision making and biases. Lastly in 2010 the Pike River coal mine explosion highlighted issues with the production verses safety paradigm (Kerin T., 2016).

These latter incidents went beyond identifying only direct root causes, but also started to identify cultural, organisational and human factors that led to the incidents. This resulted in process safety starting to engage more with sociologists and psychologist to better understand how improvements could be made beyond just engineering design. While there have been significant engineering advancements, that have resulted in safer designs, incidents continue to happen, suggesting we are still missing something in process safety management.

4 WHY DEVELOP PROCESS SAFETY CONTENT

The content in the process safety related body of knowledge chapters is not new, however this project set out to consolidate fundamental aspects into two accessible chapters. While the material existed in a range of sources, it was not reasonable to expect OHS professionals to trawl through multiple, and often unrelated sources to obtain the necessary knowledge. In an effort to make process safety knowledge accessible outside of its field it is vital to consolidate the material in a suitable reference.

5 THE OVERLAP BETWEEN THE TWO PROFESSIONS

There are many instances where there is an overlap between OHS and process safety tools or requirements. Some examples include safe work systems, management of change, procedures and training to name a few. This overlap can be a very valuable starting point to raise awareness. A detailed example is given in the OHS Body of Knowledge *managing process safety* chapter (Kerin P., 2017) utilising a liquefied petroleum gas tanker as an example. An excerpt is shown here in Table 1.

Table 1. Difference and overlap between OHS and process safety when considering a liquefied petroleum gas road tanker (Kerin P., 2017).

Concept	Process safety specialist	Overlap areas	Generalist OHS professional
Safety in design, including systems	Integrity of tank and delivery hoses, excess flow valves, breakaway protection on hoses, pressure relief, tanker overfill safeguard, electrical immobilisation, interlocks, earthing integrity during load transfer	Truck chassis design, load capacity, crash protection Site design, deluge cage design, gas and fire protection Shared understanding of requirements to ensure 'fit for purpose' design	Driver access to cab, posture issues in cab seating, weight and manoeuvrability of delivery hoses Dashboard design

6 HOW CAN WE IMPROVE PROCESS SAFETY AND OHS?

There are a number of ways in which we can bridge the gap, leading to better safety outcomes. These include cross discipline awareness, utilisation of existing tools, and structural considerations.

6.1 *Cross discipline awareness*

There are two angles to consider with cross cultural awareness. It is necessary for OHS professionals to have a greater understanding of process safety but it is also necessary for process safety professionals to have a greater understanding of OHS. This is because a singular focus from either group can introduce hazards and result in poor safety outcomes.

There is always an issue with resourcing, regardless of what part of an organising you are in. Shared resources can be leveraged to improve safety outcomes. As an example, there are usually multiple OHS personnel in an organisation that is geographically spread, while there will be less process safety specialists. Providing some basic process safety knowledge to OHS professionals means an organisation has more eyes looking at process safety. This is not to say that the OHS professionals should be solving the process safety issues, but should know enough to recognise a potential issue and raise it with the process safety professionals. The OHS Body of Knowledge process safety chapters are a starting point for this knowledge sharing. (Kerin P., 2017) (Kerin P., Process hazards (chemical), 2017).

Conversely when a process safety professional is on site or undertaking a review, the ability to recognise an OHS issue and call in OHS professionals also adds value to the organisation. The recently published OHS Body of Knowledge *Managing process safety* (Kerin P., 2017) chapter references two examples, where decisions made by one group in isolation resulted in additional hazards being introduced. In both cases, a holistic approach could have minimised these additional hazards.

6.2 *Utilisation of existing tools*

Due to the longer history in OHS, there have been many stages of evolution in tools and communication techniques. OHS professionals have also been working on the concepts of engaging workers in safety for longer and have learnt what works and what may be less effective. Some specific examples include safe work systems, worker interaction models and safety shares. All of these tools exist in one form or another within OHS systems. It is possible to extend them to include process safety elements, so that process safety is not an 'add on' to the business, but integrated within an existing way of working. A suitable knowledge of process safety is required by those using the tools, so training and coaching in this area is still important. It is also vital for participants to understand why process safety is important. If this is not understood, it is easy to gloss over or skip the harder questions, which could result in missing a vital piece of information.

Safe work systems are widely used in facilities that have both major hazard and OHS risks. A safe work system will have both OHS and process safety controls required to keep both the worker and the facility safe in the course of maintenance activities. As the safe work systems are most often owned by the operations or OHS functions, it is important to ensure that appropriate process safety considerations are included. To ensure that the systems are working, there should be a spot check process on permit that are in service as well as closed. This helps to show that the system is working or what improvements need to be made. These checks should look at both the OHS and process safety controls that are referenced.

Worker interaction models are used for a number of purposes. Where there is a model that requires discussion on safety matters in a one on one basis, this can be modified to incorporate process safety topics. This can be used to raise the awareness of process safety as well as identify potential problems. Implementing this type of addition to an interaction process does require up skilling of the people having the discussion to understand the process safety implications and why they are important. By incorporating process safety in here, process safety can be integrated without the introduction of a new system.

Safety shares are a way of showing organisation commitment by ensuring each meeting is started with a brief discussion on safety. There does need to be care taken with this model, as it can sometimes lead to a tick box mentality on safety by talking about something irrelevant just to cover the agenda item. Sometimes a better model is to have specific safety share meetings, rather than having every meeting, regardless of topic started with a safety moment. Process safety can however leverage off the concept by ensuring that relevant process safety information is available for these moments. For example in a facility that operates at high pressures, a brief discussion on how well the pressure relief devices are working from maintenance testing records would be more relevant that a discussion on wearing seatbelts in cars. While seatbelts are a valid safety topic, it is not as relatable in the workplace where no driving is done, but where pressure control is vital.

6.3 *Structural consideration*

There are multiple schools of thought on how safety resources in an organisation should be structured. In terms of where safety sits in an organisation structure, some believe that safety should report to the most senior role, others believe it should sit under the human resources or operations functions. In terms of how the safety personnel are structured, some believe process safety should sit with the engineering function while others believe it should be incorporated into the OSH function. The author believes there is no right or wrong structure and has worked under several of the models discussed. The vital element for any model is clear lines of communication and accountability. There are advantages and disadvantages to all options.

Firstly, considering the functional structure, Table 2 highlighted disadvantages and advantages. Leveraging of the advantages while managing of the disadvantages could result in better safety outcomes.

Table 3 looks at the disadvantages and disadvantages of the different structures of the safety groups. Again, leveraging of the advantages while managing of the disadvantages could result in better safety outcomes.

Table 2. Functional structure.

Structure	Disadvantages	Advantages
Safety executive	• Large size of executive • Executive may be OHS and not understand process safety or vice versa	• Potential to input safety considerations for business decisions • Safety seen as a non-negotiable like production
Safety in human resources	• Process safety is about more than people • HR executive may not be able to convey appropriate safety messages	• Small size of executive team
Safety in operations	• Operations in authority role may lead to a production over safety perspective	• Deep engagement in operational aspects of business

Table 3. Group structure.

Structure	Disadvantages	Advantages
Process safety in engineering	• Possible lack of engagement with OHS • Segregated from operational pressures	• Professionals influencing engineering designs within the group • Maintaining continued engineer professional development
Process safety in operations	• Possible lack of engagement with OHS • Difficulty in influencing operations when embedded within it	• Professionals at the worksite and accountable for operations
Process safety in OHS	• Possible lack of engagement with engineering and operations • Technical field 'lost' within general disciplines	• Integrated approach to managing safety • Leverage common systems, such as safety management system for process safety implementation • Leverage off multiple resources in an organisation looking at process safety

7 CONCLUSION

Both process safety and OHS incidents continue to occur under our current practices, so something must change if we are to reduce incidents further. One potential remedy is to bridge the divide between OHS and process safety and start to leverage improvements from both. By educating OHS professionals in the basic fundamental of process safety and vice versa, we will all gain a better understanding. This will not solve all the issues, but it offers a chance to address some. Since the launch of the chapters there has been a great deal of interest in their content. A future step will be to develop learning outcomes from the chapters, so the topics can be incorporated into higher education OHS qualifications.

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Trish currently sits on the board of the Australian National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) and is a member of the Mary Kay O'Connor Process Safety Center steering committee.

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Traditional learning vs virtual learning in maintenance operations: Thoughts and reflections from a safety perspective

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ABSTRACT: Flexibility in maintenance operations is one of the requirements for a successful management of capital asset industries nowadays. It demands both the deployment of technology, equipment and man-forces and to provide effective training to the technicians for maintaining the assets in a correct and safe way with short notice.

In this scenario driven by time-pressure and high workload, traditional leaning systems could not give the necessary agility in terms of organizational and educational solutions.

The use of Virtual Reality (VR) in the learning process could ensure the ability to react to unforeseen events that required more workers "ready-to-work", providing valuable training and ensuring comparable levels of safety.

The paper aims to explore and determine factors for testing training methods to safeguard the performance of the technicians reducing human errors and decreasing the time of training. Finally, it highlights when results between VR learning and traditional learning differ to avoid incorrect conclusions concerning the performance of the educational systems.

1 INTRODUCTION

1.1 *Why a change in the learning methods for maintenance operations?*

When new complex assets are introduced into operations, technicians require re-education for ensuring the same or higher level of performance during the maintenance operations. These training sessions are always performed under substantial time constraints, with a lack of resources and the new assets are always implemented within an existing operational schedule.

From one hand, having a more efficient and flexible training method is becoming vital for companies to always guarantee the availability of technicians in every moment; on the other hand, optimizing the financial resources allocated for training purposes becomes always more frequently.

As discussed by Galvan et al. (2010) and Kozak et al. (1993), the use of VR systems tends to be an interesting solution against previous training methods and several solutions have been already proposed in many industrial sectors as energy production (Arendarski et al. 2008; Baeta Miranda 2010; de Sousa et al. 2010; Feng and Cheng 2009; Galvan et al. 2010), manufacturing (El-Chaar et al. 2011; Guobin et al. 2010; Wu & Fei 2011) health care (Tang et al. 2007; Zhang et al. 2003), construction (Chun et al. 2008; Blackledge et al. 2011), military (da Silva Simoes & Ferreira 2011; Mukherjee & Tapaswi 2006; Rizzo et al. 2011) and mining (Squelch, 2016).

Among the solutions offered by VR, the opportunity to shorten the learning curve with proficiency-based virtual environment (Aggarwal et al. 2007) is a promising improvement from economical and operational perspectives.

However, comparing traditional learning methods (classroom education and on-the-job training) for the education of technicians with Virtual Learning methods some difficulties in the evaluation could arise and a quantitative evaluation could not be simple to obtain.

As discussed also by Estevez (2002) the cognitive aspects related to the problem mainly refer to understand the degree of applicability of their acquired knowledge within the environment for which they are being prepared.

The methods have different characteristics which are sometimes difficult to assess causing several uncertainties in understanding how the learning curve can change using a VR learning environment.

1.2 *Which are the challenges to face in terms of safety?*

Moving from a traditional training to a training supported by VR has to result in a change in educational structure within the organizations in order to ensure the expertise of technicians and the safety of the system. Dedicated Virtual Environments (VE), where the technicians can train in and practice, instructors can teach with, have to be set up. A specific job function (VR designer) should be

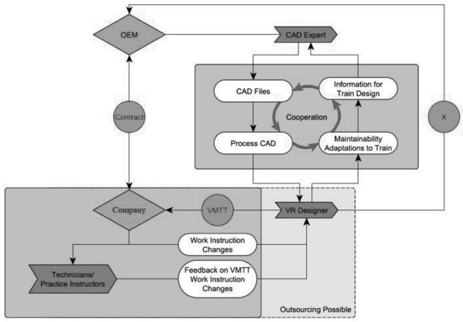

Figure 1. An overview of a possible company structure in order to adopt virtual maintenance training.

created focused only on VR to work in close cooperation with the CAD expert of the Original Equipment Manufacturer (OEM) to create, maintain and adapt the VE based on changing work instructions, maintenance procedures, and feedback from technicians and engineers (Fig. 1).

Without a similar company's structure, not only financial risks (related to the acquisition of technologies and intellectual property materials) but also relevant risks (related to inadequate training and lack of information) could generate important safety problems. Less skilled and prepared technicians rising the likelihood of human errors and an organization to able to promptly react in a reliable way.

The second great challenge for occupational education with VR is balancing the necessary skills for complex procedures (i.e. maintenance operations). It is a combination of expertise within the technical and system knowledge domain.

Moreover, as also suggested by Joy & Garcia (2000), before a switch can occur, the question must be raised whether the VR can yield proper gains considering media not only as a transfer of knowledge or also as a specific tuning to reinforce the learning goals. Results achieved by Kraus & Gramopadhye (2001) on aircraft maintenance team training highlight how media does deeply influence learning goals.

Along these lines, it becomes vital exploring the factors that influence the transfer of knowledge operated by VR for properly evaluating the results.

2 TRADITIONAL LEARNING VS VIRTUAL LEARNING IN MAINTENANCE OPERATIONS

2.1 *Traditional learning*

From a historical point of view maintenance training underwent changes in the last 40 years due to an increasing complexity of the maintained equipment. The education moved away from classrooms towards a more hands on approach of training. There are qualifications devised to judge the skills of technicians for these advanced assets. The approach currently used for training ensures the technician has an extensive background in operations and maintenance. Then the technician is hired and trained by the company to attain the required knowledge for daily operations. This is done on the actual assets. The next sections shall continue explaining the concept and the accompanying issues with this method of training.

2.1.1 *Concept and issues*

The education of technicians transfers technical knowledge of experts by demonstrations and examples of mock-ups or actual equipment.

Concept: these training sessions usually took place in the workplace and focused on the most abundant type of equipment (mechanical, electrical, pneumatic, and structural). This training method is named On-The-Job (OTJ) training.

It is considered as a semi-structured training system due to many dependencies on training asset and instructor availability and shortage of time to repair (Walter, 2000). The loss in structure undermines the knowledge gain of the technicians. There is a desire and a necessity to attend an encompassing education to satisfy the additional complexity of assets. The method changed into several modules for covering all the component types of the asset, requiring new qualifications. (Yeow Khee, 2009).

Training for a qualification starts with vocational education. This is specific job or craft oriented education which puts out technicians highly skilled in operations and maintenance of specific mechanical, electrical, or structural components.

Within this educational structure, there is room for the technicians to experience apprenticeships to attain the necessary technical knowledge to maintain equipment. Usually, the full-time education takes place from 14 to 18 years old (Steedman, 1987).

They are qualified as a basic level technician with a global knowledge of equipment maintenance. In many cases, the company that hires them provides their own vocational training to start educating technicians with more specific equipment knowledge, directing them towards the business of the company (i.e. rolling stock, aviation, refining, or maritime). These qualifications are then transferable to other fields or businesses through a European standard.

Issues: this method introduces issues into the training of technicians. Issues which reduce the effectiveness of training, decrease the amount of training knowledge transferred. For instance, young students are not educated enough to find efficacy in the transferred knowledge. Furthermore, the educa-

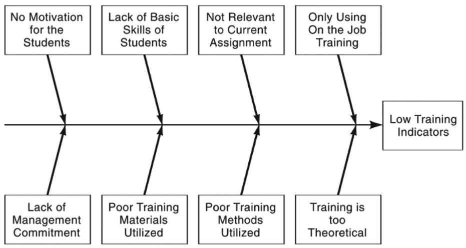

Figure 2. Cause and effect diagram indicating the issues with maintenance training.

Figure 3. Example of VR maintenance training in rolling stocks industries ('t Hart, 2017).

tion prefacing vocational training does not contain enough specific technical information, here the technicians should already be allowed to attain certain qualifications (Steedman, 1987). Then there is the issue of the knowledge gap between experts of different generations. Changes within the qualifications have resulted in a different level in knowledge and thus a genuine gap (Hampson and Fraser, 2017).

Issues cause differences in efficiency, which are frequently proven in literature but often these results are biased. Founded on inadequate methodology and consequently drawing incorrect conclusions (Joy and Garcia, 2000). It is stated that the assumption of better learning with more technology cannot be made simply. Learning effectiveness is a function of effective pedagogical practices.

When it is directly related to maintenance training the following causes shown in Figure 2 are directly related to inefficient training (Wireman, 2005)

2.2 *Virtual learning*

Virtual Learning makes use of new technology to visualize learning objects. To help the technicians to learn maintenance procedures. It is capable of clearly showing intricate components in an interactive manner.

2.2.1 *Concept and issues*

Concept: VR immerses the technician in the VE (Fig. 3). All components are represented in the virtual world. The exploration of the VE, especially of objects not accessible in reality, is a major benefit of using VR (Freina & Ott, 2015).

Additional devices can be connected to enhance the environment with the technician's hands, controllers, or mixed reality components.

Interactivity can be used to let the technicians experience more cognitive activation. The training method can, via intuitive interaction and immersive representation, anchor knowledge and skills directly to the components and maintenance procedures.

Issues: there are some problems (both technical and social-related) to solve in order to incorporate Virtual Learning in an extensive way during the training.

First of all, it requires a restructuring of the traditional learning content since a relevant amount of learning contents is not digitally transferable. The description of mechanism in traditional learning documents is extensive to substantiate the lack of visualization. VR does not have the visualization's issues but displaying large portions of textual information is not comfortable and it requires a partial re-arrangement of the learning content. As suggested by Prince & Felder (2006), the aim of the training should drive to a more problem-based learning, giving the chance to the technicians to experience the mechanisms of the assemblies through failures and errors.

Moreover, from a social perspective the users have to accept the implementation of such a technology into their day-to-day operation (Angelov et al., 2007). The adoption of Virtual Learning is often a difficult process that needs an integrated information technology system with the full support of technicians, practice instructors and engineers (Selim, 2007).

3 KEY PERFORMANCE INDICATORS (KPI) OF TRAINING METHODS

Assessing the effectiveness of a training is often difficult. The organization usually evaluates the training based on the knowledge of the technicians, on their performance analyzing faulty or erroneous behavior (mistaken diagnoses, (dis)assembly faults, and failed repair actions) (Schaper, 1998). Lack of objectivity in test and control groups, repeated samples, or prior knowledge could cause risk of objectivity in the evaluation through a muddling of the data.

However, some pitfalls of training can be assessed and reduced establishing and defining performances indicators, using them as foundations by which training mediums can be fairly evaluated.

Generally speaking, a training can be assessed based on its impacts from an educational KPI (how successfully it transfers the learning objectives) and from an organizational KPI (how much it costs to the company in terms of time, resources, money etc…).

The virtual training requires also a technology KPI related to the used systems (how it is easy to use from a man-machine interaction point of view and how it is easy to adapt to different procedures and operations).

3.1 *KPIs comparison between traditional learning and virtual learning*

Based on the studies of Phillips, J. J. P. & Phillips P. (1997) on traditional training and Emmanouilidis & Spais (2010) on Virtual Learning (supported also by the European standard ISO 25010:2011 (2011) for Systems and Software Quality Requirements and Evaluation) a KPIs comparison is provided (Fig. 4).

The comparison shows how the organizational and educational KPIs are considered essential in both the discussed forms of training. The reason lays on the primary need of transfer right knowledge to technicians and to make the training feasible and more effective as possible for the company.

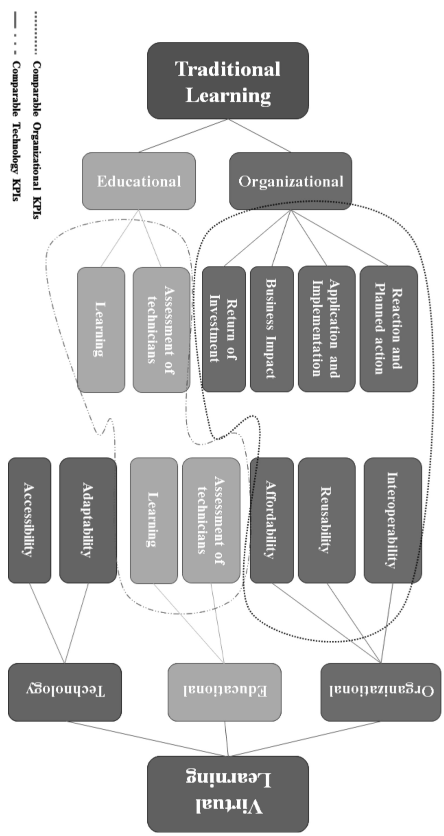

Figure 4. Traditional Learning and Virtual Learning Key Performance Indicators' comparison based on Phillips J.J.P. & P.P. (1997) and Emmanouilidis & Spais (2010).

Transferring skill/knowledge from the traditional maintenance procedure into the virtual maintenance training requires a lot of works and efforts. At the same time, assessing the benefits and the added value of a quite new learning method it is also a formidable task (Prince & Felder, 2006).

For those reasons, as anticipated, in order to have a proper evaluation of the Virtual Learning method appears vital providing also a third class of KPIs for assessing the technology involved in the process.

The following KPIs give a rough approach to the evaluation in order to include all important aspects in the performance indications.

Reaction and planned action/Interoperability: they estimate the performance related to the usefulness of gained knowledge, the efficacy of training and relevancy to the current workplace.

Application and implementation: they determine whether the gained knowledge is applied and how often, how well the technician is supported in applying knowledge.

Business impact/Affordability: established the effects of training and its benefits, an evaluation on costs, time, customer satisfaction, technician satisfaction and the return of investment for each solution has to be performed. Specifically, they evaluate time required and the benefits of its use, like improved productivity and efficiency.

Return of investment/Reusability: questions if the costs balance is in favor of costs benefits opposed to training costs.

Learning: it describes if the knowledge has been properly transferred and if the technicians are able and confident to apply gained knowledge.

Adaptability: it refers to the opportunity of the Virtual Learning method to be modified according to the needs of each installation case and to be adopted for different operations.

Accessibility: it examines the ease to find and use learning objects in a virtual environment.

4 THOUGHTS AND REFLECTIONS FROM A SAFETY PERSPECTIVE

4.1 *How can training methods be safely and smoothly introduced?*

To get the user more inclined into using the product he/she should be included in testing. Since the development of a virtual maintenance training is iterative, testing such system with actual users will satisfy their need to give input to the product (Nacke et al., 2012). If the user is neglected it can have more adverse effects. Moreover, not testing on a multitude of users can cause unnecessary development time, require multiple iterations of feedback and much more checking of the VE. Cutting out the users can reduce transparency, increase the risk of mistakes, and lessen the quality of the training effectiveness (Holmberg et al., 2010).

Nevertheless, a new learning method has to be smoothly introduced, without replacing from the beginning the traditional learning method completely. For some special maintenance operations, the complete substitution could also never happen due to the presence of specific tasks that are difficult to reproduce or to simulate in a virtual environment even with the most advanced computer graphics techniques.

From the studies conducted by ‘t Hart (2017), the virtual training for maintenance operations achieves its best results for refreshing skills training and for assessing the acquired knowledge of the technicians, saving operational time and resources.

4.2 *How can virtual training help safety in maintenance operations?*

As briefly highlighted in paragraph 1.2, Virtual Learning influences several sections of a company. It is not only technical but involves people, procedures, safety aspects and business aspects as well.

The application of a Virtual Learning method helps in maintaining/restoring proper safety levels during maintenance operations. It permits to the technicians to experience specific situations and make procedural errors in a controlled environment. Making “safe” errors during a training offers the incredible opportunity to overcome the only memorization part, letting the technicians remember not only right procedures but also wrong procedures and their effects on their job.

As described by Kolb (2014), the skills of the students (technicians can be considered as students during the training moment) rapidly increase if the educational system offers a learning cycle in which concrete experience, reflective observation, abstract conceptualization and active experimentation are present.

From a safety perspective, the presence of those moments is essential for guaranteeing a complete learning of all the aspects that could affect the maintenance operation. During the training, the technician cannot learn by simply watching or reading, but he must actually do and he needs the time for stepping back from the task and reviewing what has been done and experienced.

5 CONCLUSION AND FURTHER RESEARCH

Traditional learning is evaluated based on the quality of the technicians. Their competence is the representation of the quality of the learning method. This is not different for a Virtual Learning system.

As briefly highlighted in the paper, both methods show lack of consistent frameworks for educational evaluation. Especially, frameworks able to evaluate both methods are not available yet. This is due to change definitions of effectiveness, leading to inconclusive results.

Moreover, differences in control group characteristics increase the difficulty to state where the value is created, test users with prior knowledge, different backgrounds, or other inconsistencies which cloud conclusions. The results are highly specific per scenario, consequently the results are difficult to generalize between use cases.

Undoubtedly, the Virtual Learning methods bring additional functions for supporting traditional method. Creating an encompassing framework to assess both methods is challenging. A framework needs to fairly assess the methods, even when they function based on different media with different qualities.

Still, the virtual maintenance training should be evaluated for its technical qualities in order to add value to the learning method. It is proven that VR technology benefits the cognitive increase of the trainees (Gavish et al., 2011). For technical evaluation, many tests are available which are industry standard when it comes to software assessment.

Since, as said, an encompassing research method does not exist in the literature, the main efforts for future research should be oriented for solving this issue.

European standards on Human Computer Interaction come close to a clear effectiveness evaluation for the Virtual Learning. Traditional learning evaluation proves its value on the outcome quality of the technician.

Attributing these outcomes to the education program will be the next step and the real challenge due to the characteristics of technicians, instructors, and training methods involved.

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Training plan for volunteers in H&S

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ABSTRACT: Health and safety training plans are one of the most powerful tools to prevent occupational accidents. SAMUR-Protección Civil is the medical emergencies and civil protection of Madrid council and is composed of state workers and volunteers group. Since 2012, the volunteers group has taken an annual education plan about H&S. There was an annual compulsory course and also the rest of courses implement H&S into all the topics. All of that improved the safety culture into the volunteer group and promoted an important depletion of the volunteers' accidents. It is important to prevent altruistic activities from generating health damages that reduce capacity and affect the volunteers' quality of life.

1 INTRODUCTION

The training plans are the basis of the company's Health and Safety at Work (H&S) risk prevention policies (PRL). These plans have to be made annually, although they may be included in multi-year plans.

SAMUR—Protección Civil (SPC) is the medical emergency and civil protection organization responsible to provide medical emergency services to the City of Madrid, and is comprised of officials and volunteers. The group of volunteers is currently formed by 1,678 volunteers. Their main activity is the sanitary attention during events (see Figures 1 and 2). Their education is organized annually, being the trainers, in principal, members of the group of volunteers; they are accredited as teachers in the specialties whose personal capacities allow them to impart their knowledge. The training plan includes both an initial skilling process for the new incomes, specifically focused on providing a basic and sufficient skill-set to the new incorporations, and the continuous training and update over the years to the active volunteers.

Figure 1. Volunteers attending patients in a field hospital.

Figure 2. Volunteers at firework event.

As part of this continuous education planning, there is an annual PRL training course that is reviewed and updated on yearly basis. Since 2012, this course is mandatory for all volunteers. The trainer responsible for the course in all editions is a senior PRL technician.

This study explores the courses taught between 2013 and 2015, both inclusive, and the accidents that occurred between 2013 and 2016, studying the potential influence of this training on labor accidents during the service.

The volunteer does not have a contractual relationship with the organization, nor does he receive remuneration for his work. This should not be a reason for not training volunteers in risk prevention, especially when a personal accident in the altruistic area generates inconveniences in the professional and personal scope of the volunteer.

2 LEGAL OVERVIEW

In International Labour Organization (2006) R197 – Recommendation concerning the Promotional Framework for Occupational Safety and Health, the, paragraph 2 of this article says: 5: In promoting a national preventative safety and health culture as defined in Article 1) of the Convention, Members should seek: b) to promote mechanisms for delivery of occupational safety and health education and training; c) to introduce occupational safety and health concepts and, where appropriate, competencies, in educational and vocational training programs. This underscores the importance of international organizations in the formation of LRP at all levels and the importance of including them in a cross-cutting way in training plans at all levels.

In the European Union's strategy on occupational safety and health, education and prevention are two key factors in maintaining and improving the quality of work. In support of this strategy, the report "Mainstreaming occupational safety and health in education: Good practice in school and vocational education" European Agency for Safety and Health at Work (2004) has been published, providing an overview and seeking to provide examples of good practice from different European countries and facilitating the development of a systematic strategy to integrate occupational safety and health in education and vocational training in a unified manner in Europe.

For the European Agency for Safety and Health at Work: "The integration of OSH into education involves systematically including it in the lessons in the classroom. Ideally, it should be part of the daily lives of students, parents and employees. If children begin to gain knowledge about health and safety as they learn to read and write, this subject will be a natural part of how they work, play and live. The children will develop a good health and safety attitude that will accompany them throughout their working lives. "Although these statements are more oriented to the integration of training in PRL in schools and vocational training, it can be extrapolated to the training received by the volunteers, being even more relevant since it is an unpaid work and that the injuries and illnesses are generated from the same will affect their personal and professional life.

In October 2015 the new Spanish law on volunteering was approved (see Ley 45/2015, in Spanish). In its article 10. b) it specifies as the right of the volunteer: To receive at all times, in charge of the volunteer organization, and adapted to their personal conditions, the necessary training for the correct development of the activities assigned to them. Article 11. j) As a duty of the volunteer: Comply with the existing safety and health measures in the voluntary organization.

3 EDUCATION PLAN IN H&S

SPC volunteer training is structured in:

– Initial compulsory training, aimed at new volunteers who join the service. This training consists of eleven modules with a total of 80 hours plus 30 hours of distance classes (see Figures 3 and 4).
– Continuous education, directed at current volunteers and composed of different courses and sessions that are offered quarterly and which include an annual mandatory course in PRL whose contents vary each year.

Figure 3. Initial compulsory course.

Figure 4. Initial compulsory course.

In 2012, it is considered the importance of including, in the training of volunteers, subjects related to the PRL, being integrated in the planning of the training since 2013.

3.1 *Description of specific PRL courses*

In 2013, the first compulsory course on self-protection and emergency plans was included in training planning. The interest of this course for volunteers is the awareness of the risks present during the activity and the need to implement self-protection measures to avoid accidents. The course was of 10 hours and was structured in the following subjects: foundations of the citizen and corporate self-protection, related regulations, structure of a plan of self-protection and of an emergency plan, risk assessment and action to accidents. In order to give training to all the volunteers, 15 editions were carried out, which were attended by a total of 1287students. The course evaluation was carried out by the students of 3.20 out of 5. The main objectives of the course were: sensitization with the importance and the need to integrate the concept of self-protection both in their work as a volunteer and in their personal lives, the knowledge of the different types of risks and the assessment of the level of risk at the beginning and during the evolution of a service, the ability to recognize the functions of the responsible and teams in an emergency plan and the different parts of the same as well as the improvement of the volunteer's response to an accident occurred during its activity.

In 2014, the compulsory course was about road safety. This issue is especially important for the reduction of accidents during the work of volunteers, since a significant number of accidents during service are traffic accidents. On the other hand, SPC has the competences of attention to victims in the public way and in the public premises of the city of Madrid. Therefore, a large number of actions present risks related to road safety, both in the movement and during the care of the victims. The course was of 10 hours and was structured in the following subjects: vehicle review, physical and mental conditions of the driver, active and passive safety, related regulations, signaling and scene control and transport pathophysiology. To give training to the volunteers, 15 editions were carried out, attended by a total of 851 students. The students' evaluation of the course was 3.75 out of 5. The main objectives of the course were: to know the phenomenon of road traffic accidents and legislation on road safety, to know and detect the causes of road accidents and road risks during emergency vehicle movements, to promote safe driving habits, all of them in order to reduce the number of accidents and injuries suffered by the volunteers in the performance of their activity.

Figure 5. Biological hazards course.

The compulsory course in 2015 focused on exposure to biological hazards (see Figure 5). The course was 5 hours long and it was structured in the following topics: epidemiological chain, methods and transmission, standard and specific precautions according to the route of transmission, hand washing (Ailiff technique), use of hydroalcoholic solutions, personal protective equipment and actions in case of work-related accidents with biological risk. To give training to the volunteers, 15 editions were carried out, attended by a total of 429 students. The course evaluation, carried out by the students, was 3.47 out of 5. The main objectives of the course were: to minimize the risk of cuts and punctures, to know the legislation related to biological risk, to identify the characteristics of biological agents in relation to their survival, transmission and damage capacity for the worker, to publicize the main prevention and control measures, to bring volunteers closer to effective use of the existing safety devices in the service, to know the importance of hand hygiene in the prevention of nosocomial transmission, to make the correct use of the gloves as a two-way protection measure and to know the recommendations and protocols of post-exposure after an accident with biological risk, all of them in order to reduce the transmission between the patient or the environment and the volunteer.

3.2 *Integration of PRL in the continuing training of volunteers*

The current volunteers have another annual training plan called continuing education, which is divided into: certificates of professionalism (oriented to the issuance of a vocational qualification) and courses and formative sessions of review, extension of knowledge and specialization.

All the continuous training has been improved and configured so that in all matters and training actions will seek the integration of safety and health at work.

Prevention must be integrated in all areas of work and similarly, in the new regulations related to volunteering, it is indicated that what should be about prevention must have at least the same characteristics as paid workers. This also implies the integration in all the formations so that it is integrated in the different aspects of the volunteer.

4 VOLUNTEERS ACCIDENTS

4.1 *Introduction*

Between 2010 and 2016 there have been 78 accidents of volunteers registered by the service. Most of them have been minor bruises, sprains and injuries. The damage has been classified according to Annex II: ESAW (European statistics at work. Classifications guidelines), Eurostat. Methodologies & Working papers. (2013). Table 1 and Figure 6 show the classification of the accidents suffered by SAMUR-PC volunteer in the 7 years studied compared to data from the European Union (EU) in 2014.

The ESAW classification differentiates the types of injuries between:

- *Wounds and superficial injuries (WSI):* contusion, bruise, haematoma, lacerations, open wounds…
- *Dislocation, sprains and strains (DSS):* all acute musculo-skeletal problems due to overexertion of muscles, tendons, ligaments and joints.
- *Concussions and internal injuries (CII):* all internal injuries without fracture, i.e. all internal contusions, haemorrhages, lacerations, ruptures to the brain and internal organs.

Table 1. Injury suffered by volunteers between 2010 and 2016 compared to data from EU in 2014.

Injury (%)	Volunteers (2010–16)	EU (2014)
WSI	21.8	30.0
DSS	41.0	27.2
CII	16.7	17.2
BF	5.1	11.5
SH	0.0	3.5
BSF	2.6	1.8
MI	5.1	0.8
TA	0.0	0.5
PI	2.6	0.4
ESVP	0.0	0.1
DA	0.0	0.0
EETLR	0.0	0.0
OTHER	5.1	7.0

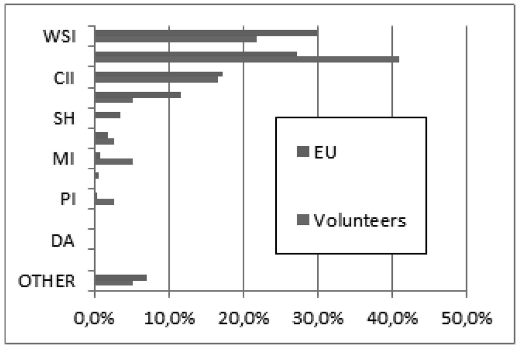

Figure 6. Comparation between the percentage of volunteers' injuries (2010 and 2016) and European workers in 2014.

- *Bone fracture (BF):* closed and open fractures.
- *Shocks (SH):* shocks after aggressions and threats, Traumatic shocks, other types of shock.
- *Burns, scalds and frostbites (BSF):* burns from hot objects or open fire, chemical burns (external burns only), effects of reduced temperature (frostbite).
- *Multiple injuries (MI):* this group is restricted to cases where two or more equally serious types of injuries are contracted by the victim.
- *Traumatic amputations (Loss of body parts) (TA):* amputations and crushing injuries, enucleations including traumatic avulsion of the eye and loss of ear(s).
- *Poisonings and infections (PI):* the acute effects of the injection, ingestion, absorption or inhalation of toxic, corrosive or caustic substances; bites of venomous animals; asphyxiation by carbon monoxide or other toxic gases, infection by virus, bacteria and other infectious agents.
- *Effects of sound, vibration and pressure (ESVP):* partial or total loss of hearing, effects caused by pressure and water pressure (barotrauma), sound trauma, pneumatic hammer syndrome etc.
- *Drownings and asphyxiations (DA):* asphyxiation or suffocation by compression, constriction or strangulation; also includes asphyxiation by suppression or reduction of oxygen in the surrounding atmosphere and asphyxiation by foreign bodies in the respiratory tract.
- *Effects of temperature extremes, light and radiation (EETLR):* the effects of excessive natural heat and insulation (heat strokes, sunstrokes) or man-made heat, effects caused by X-rays, radioactive substances, ultraviolet rays, ionizing radiation, welder's eyes, accidental hypothermia and other effects of reduced temperature.
- *Other:* other specified injuries not included under other headings.

These data indicate that most of the cases are caused by small vehicle accidents, falls, aggressions of patients and up to 8 occasions that have caught the fingers with different elements of ambulances (benches and doors).

The investigation of causes is quite shallow but from the data obtained in most occasions the origin is casual or by lack of the own volunteer or of another companion, in other occasions they are caused by bad postures or loads of inadequate masses and finally 4 cases were caused by a lack of use of higher protection material.

If we compare this data with Richard, Marsh and Moore (2011), with respect to the data provided by accidents suffered by paramedics and emergency medical technician in the interval of 2003–2007, in this case, 84% are DSS, about double ratio compared with our results.

4.2 *Demographic data of the victims*

54% of the injured are males and 46% are woman (see Figure 7), while within the total number of volunteers 56.3% are men and 43.7% are woman.

Regarding the age of the injured, the median is 27 years (P25 = 22, P75 = 35.75), according to the study of Navarro López-Fando, Zubillaga Carmona, Feital García, et al. (2017) (in Spanish), SAMUR-PC volunteer health care the new volunteers are 42.9% under 30 years. If we compare the age of the injured with the same suffered in the United States (Table 2) between 2010 and 2014 (using data published on NIOSH website (the National Institute of Safety and Health) stands out a greater percentage of victims under 25 years, this figure is related by a higher percentage of volunteers between 18 and 25 years (matching their voluntary activity with their studies) than persons who work as a paramedic and Emergency Medical Technician. Involvement in volunteer work over 35 is also lower, reflecting fewer accidents compared to NIOSH data (The National Institute for Occupational Safety and Health NIOSH, 2010–2014).

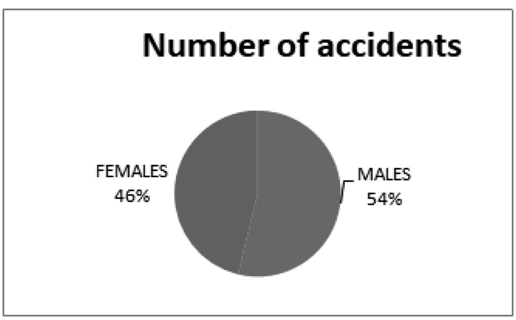

Figure 7. Distribution by sex of the injuried volunteers.

Table 2. Injury suffered by volunteers between 2010 and 2016 compared to data from EU in 2014.

Age (%)	Volunteers (2010–16)	NIOSH (2010–14)
<25	37.2	18.3
25–34	35.9	36.1
35–44	19.2	25.5
>44	7.7	20.1

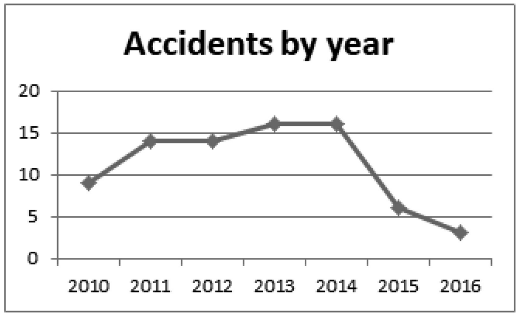

Figure 8. Caption of a typical figure. Photographs will be scanned by the printer. Always supply original photographs.

4.3 *Accidents evolution*

From 2010 to 2014 there is a growth in the number of accidents suffered annually by the volunteers during their work in the Emergency Medical Service, but once the prevention training program has been fully implemented, there has been a drastic reduction in volunteers' accidents, both in the number of accidents and in their severity (see Figure 8).

5 OTHER MEASURES

5.1 *Information*

Since 2016, awareness campaigns and promotion of good habits have been included. These documents are located in several places of our headquarters, in addition to being all placed in an information panel in the access to the locker room building.

In this way the preventive culture that is so important is promoted to improve the accident data in companies.

5.2 *On-site supervision*

In the service of volunteers we have two figures who go with the volunteers to some services and perform tasks of coordination and supervision of them, These are the Head of Quality Division whose task is to correct and reorient some actions to avoid errors and improve health care made by volunteers and workers to citizens and the head of team coordinating voluntary activity, that their role in this regard Is to go to covered services with volunteers and confirm the correct coordination with those responsible for other emergency services and also must notify the service in the event that a volunteer suffers an accident during the performance of their service.

How margin of improvement could be encouraged that these people fomented the preventive culture. Correcting and indicating areas for improvement during their performances, or at the end. In this way, the training and information actions implemented in the present time will be complemented with recommendations focused on the needs of the volunteer at specific moments.

In order to make this possible, it is necessary to provide training to those responsible for PRL, in addition to observation and correction techniques. Thus, this criticism is as constructive as possible and helps to enhance the preventive culture of the service and especially of the volunteers.

So far the Heads of Division of quality carry out evaluations of the units' intervention, but these assessments are recorded days later and volunteers' access to them is neither easy nor habitual. Therefore, seeking improvement in prevention, the indications referring to these issues should be corrected at the time and the relevant indications made.

Thus, good practices are reinforced and errors are limited in addition to facilitating the early detection of errors that must be reinforced during the corresponding formations to avoid future accidents.

6 CONCLUSIONS

Training in occupational risk prevention should be implemented in all activities carried out by both labor and voluntary. To prevent altruistic activities from generating health damages that reduce capacity and affect the quality of life of volunteers.

Training in Occupational Risk Prevention must be specific in those aspects that generate mortal or very serious risks and in those that are repeated in a systematic way and that are therefore the cause of a significant number of accidents. This training should be mandatory for all members of the organization.

The instructions and procedures should be incorporated into the rest of the formations, giving the same instructions to the volunteers, Avoiding giving contradictory instructions that could generate doubts or make them not comply.

The planning of training in the Prevention of Occupational Hazards in the long term (5 years) generates a significant reduction in the number of accidents, not only with respect to accidents directly related to the training received, but being a much broader sense since Fosters a preventive culture among volunteers.

The activities related to the promotion of a preventive culture must be carried out in three areas: specific training, integration in all training and awareness-raising campaigns on specific subjects.

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Safety training parks—a case study on the effectiveness of the trainings

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ABSTRACT: The Safety Training Park (STP) concept is a unique Finnish safety training innovation. The STP provides different actors of the construction industry and other branches a practical Occupational Safety and Health (OSH) training area. To the authors' knowledge, no such parks exist in Europe besides Finland. Objective was to study the effectiveness of the STP trainings at a large case company which participated in this study and which has actively trained its personnel in the park. The study was conducted from February 2015 to February 2017. Several key success factors were identified in the interviews of this case study. In addition, the company OSH statistics (2010–2016) showed a positive development at safety level. However, The Nordic Safety Climate Questionnaire did not show any significant change of results in a one year period. According to the results of the group interviews the learning possibilities in the STP was evaluated positive most of the persons in groups. Especially it was seen very useful for students and for everyone who needs introduction for safety.

1 INTRODUCTION

1.1 *Background*

The construction industry is amongst the most unsafe industries worldwide. In addition to its high risk for accidents, construction work contains several physical and psychosocial load factors that might affect the ability to work. A novel approach to safety training has been created by a variety of stakeholders in the Finnish construction industry.

The first safety training park (STP) in Europe Rudus Safety Training Park (RSTP), was constructed in 2009 in the city of Espoo in southern Finland. RSTP was followed by a STP in northern Finland (STPNF) in 2014, jointly designed and created by 80 stakeholder organizations in the city of Oulu. A third STP is currently being constructed in joint cooperation with stakeholder organizations in eastern Finland. STPs are also planned in Sweden and Denmark.

The STP concept is a unique safety innovation by which different actors of the construction industry and other branches can be trained on practical level to perform different work phases safely at construction sites. The study is based on design science premises, i.e. the aim is to provide up-to date and valid information that can be used for improving current training parks and reasoning (or unreasoning) new training park initiatives. In order to study such a complex issues a multidimensional approach with both qualitative and quantitative measures is needed. (Bisantz & Drury 2005; Hale et al. 2010; Pedersen et al. 2012a, Pedersen et al. 2012b). A realistic evaluation was chosen as the methodological framework for this study, as it allows such multidimensional approaches and as it has been utilised earlier in different OSH studies. (Pedersen et al. 2012a, 2012b, 2014; Kvorning et al. 2015).

The idea behind the construction of the park and the learning objective of each traing station has been descriped elsewhere (Reiman et al. 2017). Moreover, another paper will report the result of the whole project (Räsänen et al. 2017).

1.2 *Method and objective*

Method of this study is based on a realistic evaluation framework was utilized. As the specific methods The Nordic Safety Climate Questionnaire (NOSACQ-50), company OSH statistics, and individual and group interviews were used.

NOSACQ-50 is a tool for diagnosing the occupational safety climate and evaluating safety climate interventions. (NOSACQ, kts. Kines et al. 2011).

Objective of this paper was to study the effectiveness of the STP trainings at a large case company which participated in this study and which has actively trained its personnel in the park. This large company represented facility services and was one of the seven companies that participated in the study. The study was conducted within two years period, from February 2015 to February 2017.

2 RESULTS

2.1 *Occupational safety climate*

Several key success factors were identified in the interviews of this case study. In addition, the company OSH statistics (2010–2016) showed a positive development at safety level (Fig. 1). However, The Nordic Safety Climate Questionnaire did not show any significant change of results in a one year period. According to the results of the group interviews the learning possibilities in the STP was evaluated positive most of the persons in groups.

2.2 *Individual and group interviews*

Experiences of the practical implementation and effectiveness of safety training were collected from supervisors and employees who participated in the training rounds, by focus group interviews before and after the training (about one month and about one year after training) (Langford & McDonagh 1997; Haslam 1997). Additionally, a focus group interview was conducted on a target group that did not participate in the safety park training. Contacts to the interviewees and consent to the interview were obtained through the organization's personnel administration and/or the safety organization. The interviews were recorded and transcribed for later analysis.

Observations that support learning according to the interviewees can be presented in the following table (Table 1).

As shown in Table 1, a total of 20 different learning findings were presented in the company's interviews. These findings were divided into two different

Figure 1. Different types of work stages in Oulu Park (STPNF) (Photo: Arto Reiman).

Table 1. The observations that support learning.

How STP supports learning	D1	D2
Demonstration of accidents and clear presentation of problems and protection	x	
Influencing the atmosphere and attitudes	x	x
Very useful especially for students		x
Good orientation for everyone		x
Good presentation of personnel protective equipment, epoxy treatment gloves		x
Working on the roof, various fixing mechanisms, use of safety harness, rack and ladder work		x
Useful for designers and architects		
The importance of occupational safety in business is highlighted		x
Order and cleanliness	x	
The risk of collapse of excavators and how to protect them	x	
Videos about work and protection are useful		x
Impact on home and leisure time accidents	x	x
The training point describing the explosion of the cement pump hose is useful		x
Electrical safety issues	x	
Hazards related to work machines (loading shovel)	x	
Dummies are a good thing		x
The practical training possibility (testing) of performing a job safely would be a good addition		x
Good place to meet and think together about sefety issues		x
The effect of hurry and stress on safety	x	
TOTAL	8	12

interviews. The first interview (D1) was conducted about one month after the visit in STP and the other interview (D2) a year after the visit in park. There were no big differences between the interviews, things were well remembered even one year after the training. In a company studied in this paper, even more learning-related issues came to mind one year after training than in an earlier interview.

The most important learning-supporting issues in the safety training were illustrative job descriptions and demonstration of accidents and clear presentation of problems and protection (see Figure 1).

> *"It is good and funny idea to have those dolls in every training points, it will tell you what it is the problem."*

Almost all participants in the interview highlighted the usefulness of the park especially for students and considered it a good orientation for all those in the field.

> *"Especially if you have just come to working life, so yes, some useful things comes up."*

The good presentation of protection and personnel protective equipment was emphasized in the interviews. A park round can also have an impact on the safety climate and attitudes.

> *"The importance of the use of protective equipment is highlighted. So surely these good examples of the right way of doing things stay in mind."*

Presentation of the risk of collapse of excavation and support of them (see Figure 2) is also useful in the park.

> *"It's scary training point. Really. It came to my mind that when those trenches are made even in leisure time. It does not come to mind when digging foundations that it can collapse."*

The observations which do not support the learning according to interviews can be presented in the following table (Table 2).

Participants in several focus group interviews thought that participants in the safety park rounds should have been activated more during the round. It was suggested, among other things, to test harnesses or other protections and to search for faults in small groups.

> *"Somehow I got the impression that we will do some exercises there and not just looking at it."*

The size of the group should also not be too large for learning not to be difficult

> *"Maybe, a smaller group would be more effective in learning. When the 15 people there are talking with each other, so it is quite hard to concentrate to the point."*

Figure 2. The trench supports for the excavators in Espoo (RSTP) (Photo: Tuula Räsänen).

Table 2. The observations which do not support the learning.

What kind of shortcomings there are in present STP training?	D1	D2
Weather conditions	x	
Trainers should be more actively involved during training. Testing of equipment and things in different training points is missing, just watching.		x
Too big group on rounds, round should be done in smaller groups		x
Fire extinguishing training points were missing	x	
More sample examples of cleaning, now more man-made park		x
TOTAL	2	3

2.3 *Company OSH statistics*

As part of the research material, numerical data from occupational health and safety indicators were collected from the target companies. Numerical research data was collected in two phases: 1) the key safety figures for 2010–2015, broken down annually, and 2) the 2016 key safety figures. Key safety figures were collected through online questionnaires targeted at corporate executives. In addition to the target companies, the same form was also sent to all other STP Northern Finland member companies. Businesses were asked to match the indicators that were monitored in the company. Not all of the key safety figures were received from the companies.

It was possible to collect numerical data most probably only for the accident rate (Figure 3).

Accident rate has clearly fallen by all target companies over the period 2010–2016 (Figure 3). The target company E is the only company that provided the ratings for each year over the period under study. The comparison data used was the nationwide, publicly available accident rate data of the RT (Construction Industry). RT's key safety figures are based on a local, annual questionnaire for member companies. According to the t-test of the student (t = 0.52763. P = 0.609261) there is no statistically significant difference between the nationwide accidents rate development of the

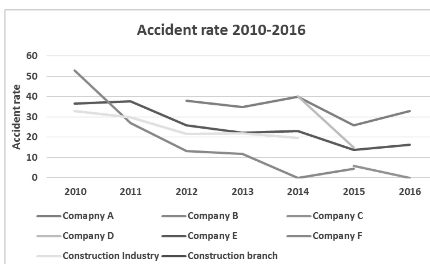

Figure 3. Accident rate of the company been studied (D) compared to other companies been studied and construction industry.

target company E and RT used. Company D's accident rate has dropped from 40 to 15 in 2014–2015.

The collection of data showed that practices in companies of collecting occupational safety and health data is varied. The material does not allow for a wide-ranging impact study from a larger group of companies.

3 CONCLUSIONS

The results of this study indicate that a company can by actively using the park for safety training purposes have a positive OSH development. As a proof of a belief in the effectiveness of STP trainings several educational institutions and organizations representing broadly construction industry in Finland have adopted Training Park training into their curriculums.

The scientific contribution of this study is related to the effectiveness of occupational safety training in the safety parks. It is assumed that the security parks are a good learning environment for occupational safety training. This study can have an impact on how, for example, the work safety training of construction companies is developed and how (with what methods) impact will be measured in the future. This study will be used to further develop of safety parks, for example, in a more activating direction and in the construction of training points describing the various stages of work.

The study results can be used to design and realization of material concerning to the park. Digital learning platforms and games can also be utilized for this purpose. It enables participants in the safety training to learn more about the importance of different cases for occupational safety and health. This is hoped to have an impact on the fact that the things that are seen and heard in training remain in the mind and affect behavior in work situations. Safety parks can also be used in building design and production planning.

Improving occupational safety in companies reduces the number of workplace accidents and the sick leaves due to them. This results in less human suffering and cost savings both for companies and for society as a whole in the form of reduced heath care and rehabilitation costs. Therefore, all the means to achieve this result are welcome. Occupational safety orientation and training in safety parks can have an effect on company and society economics if the parks are widely used by work places.

Data has been collected by using three different methods in this study. Interview material can be used in the future when new studies into safety related learning methods is being planned. The results of the safety climate survey were, in some respects, somewhat weak due to the poor response rate.

The results of the study emphasized the usefulness of the safety park for schoolchildren and students as well. In addition, kindergartens could visit the park. Prevention of home and leisure time accidents would also be well suited to this connection. It would be desirable to develop the park to a more experiential and experimental way. The park could therefore be a learning environment for children and young people in different learning phases. Park training is also very well suited for guidance and training at various stages of the career.

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A concept for developing safety leadership competencies of the managers

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ABSTRACT: Safety leadership is a key to safety culture transformation and safety performance improvement in organizations. Managers have an essential role in implementing the safety policies and procedures of an organization. Thus, to be able to truly improve the safety performance of an organization the safety leadership behavior must be improved. The objective of this study is to construct a safety leadership training concept to develop safety leadership competencies of line managers. The requirements of the concept were built based on previous literature on safety culture, safety leadership, management of change and safety performance. Moreover, it utilized information on the good practices from previous extensive safety improvement projects in the target organization. The study focuses on managers that are responsible for the safety performance.

1 INTRODUCTION

Safety leadership is defined as a process of interaction between leaders and followers, through which leaders can exert their influence on followers to achieve organizational safety performance goals (White 2016). Safety performance improvements can be achieved through cultural change (Fizgerald 2005). Managers' active role is commonly considered one of the key elements of successful safety management and culture (Biggs et al. 2013, Fernández-Muñiz et al. 2007). Managers' ability to effectively communicate the organization's safety vision, values, expectations, and standards is critical for safety culture transformation (Biggs & Biggs 2013, Hale et al. 2010, Hardison et al. 2014).

Traditionally safety improvement efforts have focused on the engineering aspects of safety. Unsafe mechanical or physical conditions are however responsible for relatively few accidents (10%) while the most accidents and injuries appears to result from employees' unsafe acts (Wilpert 1994). Thus, while human errors does contribute to accidents, the behavioral causes of failure plays the bigger part when causes of the incidents are analyzed (Pidgeon 1991).

Nevertheless, current work life presumes managers have different types of safety management and leadership competencies (Conchie et al. 2013, Hale et al. 2010). Moreover, managerial authority is seldom a sufficient basis for gaining the subordinates' commitment to safety, since success as a manager also involves leadership (Tappura & Nenonen 2014, Yukl 2010). Therefore, managing safety is about mastering the both aspects of safety management and safety leadership.

Safety leadership is a key factor in promoting safety culture and safety performance in organizations (Barling et al. 2002, Kapp 2012 Tappura & Nenonen 2014). Previous studies have stated that safety leadership not only promotes safety participation and safety compliance of employees but also has a positive effect to the productivity in organizations via improved safety performance (Clarke 2013, Grif-fin & Hu 2013, Kapp 2012). Hence, managers' safety leadership skills should be emphasized to improve organizational performance (Tappura & Nenonen 2014).

The traditional leadership facets of transactional and transformational leadership are suitable construct for safety leadership (Barling 2002, Clarke 2013, Kapp 2012, Tappura & Nenonen 2014). Safety specific transformational leadership can affect the subordinates' awareness of safety issues at workplace as well as their perception of organizations' policy and practices concerning safety. This was seen to lead to less safety related incidents (Barling 2002). In addition, this type of safety-specific transformational leadership improved safety outcomes and enhanced the safety participation of employees (Mullen & Kelloway 2009). Therefore, the study shows the link between transformational leadership and enhanced safety performance.

Effective safety leadership is not only the combination of transformational and transactional leader-ship styles but also depends on the credibility and vision of managers as well as their safety commitment. Credibility of management depends on the employees trust in management. The importance of employees' trust in management for workplace safety has received increasing attention within the literature (Conchie & Donald 2009, Conchie et al. 2013, Zohar 2000). These studies show that trust in management increases employees' engagement in safety behaviors and therefore reduces rates of accidents.

Many studies show that the management's safety commitment has also a crucial influence on organizational safety (Christian et al. 2009, Fruhen et al. 2014, Krause & Bell 2015, Michael et al. 2005). Managers' commitment to safety can be induced by enhancing the managers' own understanding of their safety tasks and supporting their resources (Tappura et al. 2014, Tappura et al. 2017). Top management should ensure that lower level managers are aware of their safety responsibilities and capable of fulfilling the requirements (OHSAS 18001:2007). Therefore, top management must ensure provision of the support, resources and guidance for the middle and frontline management levels, for example, in the form of management training (Tappura et al. 2014).

This study discusses safety leadership development in an international power and automation technology company. The aim of this study is to construct a safety leadership training concept to develop safety leadership competencies of line managers. The objective of the concept is to assure that the managers are capable to lead a successful change in safety culture. The requirements of the concept were built based on previous literature on safety culture, safety leadership, management of change and safety performance. Moreover, it utilized information on the good practices from previous extensive safety improvement projects in the target organization. The future development of the training concept is also discussed.

2 MATERIALS AND METHODS

This study is based on the literature and empirical findings from a study in an international power and automation technology company. The motivation for the company's participation in the study arose from their dissatisfaction of the current safety performance in certain facilities. Thus, a new safety approach was initiated to change the safety culture, and emphasis on safety leadership was increased. The study was conducted as a thesis work in one of the global divisions of the company on spring 2016. For the concept pilot, four facilities of the global division took part.

The safety leadership development concept design and construction is built on three individual work tasks; the concept's requirements, the construction of the concept and last the concept piloting. First, the theoretical background forms the base for the concept. The lead author of the study performed a literature analysis and outlined the current theories used in safety culture improvements. Thus, the theories of managing safety, safety culture, management of change and safety performance measurement sets the perimeter on which the concept is constructed. Thus, all legal requirements or guidelines are fulfilled and theories for potential building blocks of the concept are taken into consideration.

However, theory is only one part of a successful concept, also practical information about different approaches were evaluated by the lead author and included in the concept requirements. Therefore, company's prior safety development projects were analyzed and evaluated and information about the benefits and drawbacks of cases were gathered. The global division HSE Manager and the regional Director of HSE were interviewed about the prior safety development projects and information about the used procedures and executed actions in these pro-jects was gathered. All the collected information and final transcript was later reviewed and validated by the regional Director of HSE.

The construction of the concept takes into account both theoretical knowledge and empirical findings from the previous safety development projects. The construction of the concept was designed by the lead author and approved for launch by the global division HSE manager.

Pilot was designed to collect feedback from the concept and ensure that the concept requirements and construction design support the local business units in creating a true safety culture improvement in their facilities. The regional Director of HSE and the lead author executed the pilot of the concept. Four facilities took part in the pilot of the first module for General Managers. Attending was the Plant manager or General Manager from each facility but also few operations managers. Overall, nine managers took part in the first module of the concept pilot.

For the second module of the concept, designed for HSE Managers, the HSE managers and coordinators from each four facilities took part. Final concept design was evaluated after the pilot for General and HSE managers and the improvements to the concept were made according to the feedback.

3 RESULTS

Theoretical background forms the base for the concept. The basic requirements for the concept, collected from literature are presented in Figure 1.

The gaps between the previous safety improvement projects and the new requirements gathered

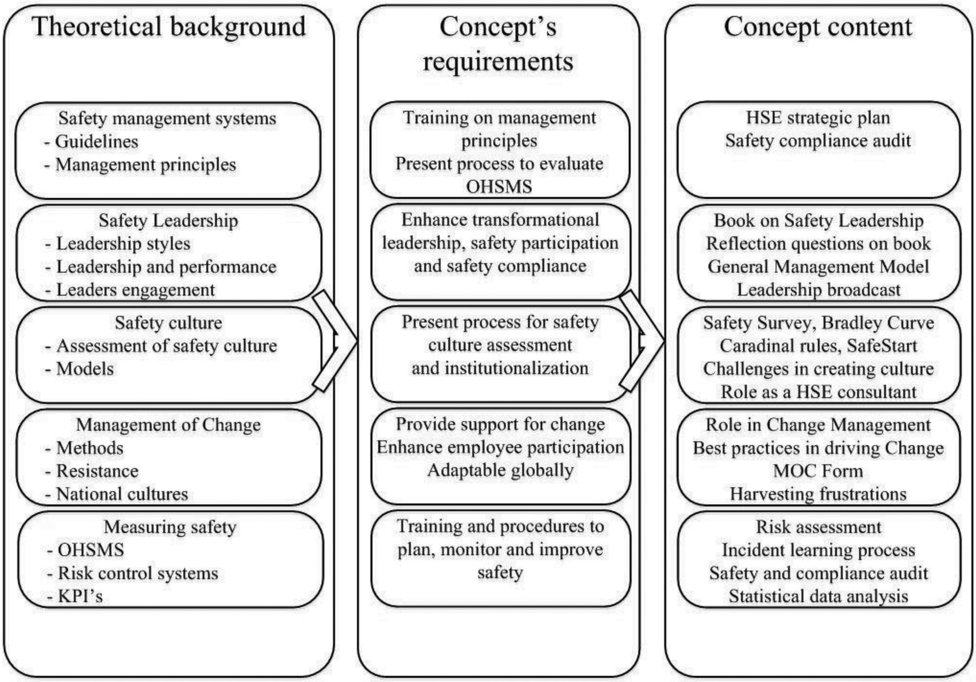

Figure 1. Concept requirements and content.

from literature were analyzed. Few key themes were missing, namely safety leadership, knowledge on how to assess and improve safety culture, and management of change. These themes had to be included to the new concept to assure that the managers are capable to lead a successful change. Therefore, the requirements of the concept were further developed as individual training content for the concept. The constructed training concept includes training on leadership and culture change, provides tools to improve safety and supports drafting of the HSE strategic plan described in Figure 1.

The general concept design described in Figure 2 includes separate training modules for General Man-agers and HSE managers. Important part of the construction is the sponsorship that extends from the first module to the execution phase. The role of the sponsor is to support and advice managers in their culture change. Before managers participate in the training modules, they perform pre-work in their facilities. The idea of the pre-work is to gather information about the current situation of the safety performance in their facility. This works as a reality check to managers but also highlights the problems the facilities are having.

The first module is for General Managers and includes training on leadership and culture change,

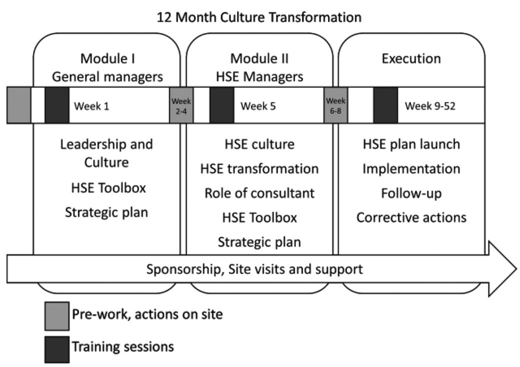

Figure 2. Construction of the concept.

provides tools to improve safety and supports drafting of the HSE strategic plan. After the training, General Managers return to their plants with the drafted strategic plan and refine the plan with HSE and line managers. General Managers also design a heat map that states the current situation and the de-sired state of safety performance. This heat map is also used to follow-up the progress of the actions as well as the improvements of the performance.

The second module is designed for HSE managers. The module includes training on HSE culture and tools to improve it, introduces the challenges managers might face in this culture change and discusses the roles and responsibilities HSE managers have in this change. After the training HSE managers return to their facilities and together with General Managers finalize the HSE plan so that it meets the set targets. HSE plan is launched and implementation of the improvement actions started. Important is to keep the follow-up up-to-date and implement the corrective actions.

The detailed design of the concept is also separated to two modules as presented in Figure 3 and Figure 4.

In General Manager's module the pre-program and day 1 concentrates on the reality check of current safety performance and personal management commitment. The objective is to awake the interest of managers to make improvements both in safety performance and on personal level. The discussions about safety leadership provides the participants the opportunity to change views and ideas with others and therefore enhances the knowledge of leadership role. This part of the module plays an important role, since the success of culture change depends on the leader's ability to notice the need for change and understand his role in it.

The second day of the module harnesses the managers with tools to improve the safety performance and culture in their facility. Incident learning process guides the managers to focus on the priority areas of safety and to evaluate the performance of their OHSMS. The Harvesting frustrations process helps the managers to improve safety participation and engagement of employees, which is a crucial part in successful change. Introduction to the manager role in change management provides the basis for HSE strategic development and day 2 the tools that can be included in the HSE plan. For institutionalizing the change, the module provides a program to be implemented in the facilities. The detailed design of the module 1 is presented in Figure 3.

The module for HSE managers includes the same processes and trainings as in the two day General Manager's module. However, the HSE managers need more training on concrete actions to improve safety in plant level and more understanding of their roles in managing change. Therefore, some key elements on creating safety culture and driving chance are introduced and the length of the module expanded to four days.

The HSE managers are encouraged to redesign their role thus concentrate more on introducing ideas and actions to improve safety rather than trying to execute safety actions by themselves. This shift in mindset is an important part of culture change thus, it is also emphasized in safety culture theory.

The tools introduced in this module are more de-tailed and focused on mastering the process and the data as in the General Managers' module. This

Pre-Program	Module I - General Managers				Post-Program
	Day 1 - Culture		Day 2 - HSE Toolbox & Planning Forward		
Safety Survey, Risk Assessment, Safety Leadership Book & Reflection Questions on book	08:00-08:20	Why the culture change concept?	08:00-08:15	Reconnect	Heat map- template Establish12- Month HSE Strategic Plan
	08:20-09:45	Bradley Curve Diagnostic, Program Roadmap	08:15-09:45	Current Reality of Incident Learning Process, Your Role in ILP - Best Practices Case Study Video	
	15'	Break	15'	Break	
	10:00-10:45	Group discussion about Safety Leadership book	10:00-11:10	Employee Engagement - Harvesting Frustrations	
	10:45-12:00	Safety Survey Results, Process Initial Reactions, Contrast to Risk Assessments	10:00-12:00	Role in Change Management	
	12:00-01:00	Lunch	12:00-01:00	Lunch	
	01:00-02:45	General Management Model (GMM) Work on Culture using GMM Model	01:00-03:00	Introduction to HSE Strategic Plan, Creating HSE Strategic Plan	
	15'	Break	15'	Break	
	03:00-03:45	Sponsor's Roles & Responsibilities	03:00-04:15	Introduction to Change institutionalizing program	
	03:45-05:00	Creating HSE Point of View, Presentations and Feedback	04:15-05:00	Next Steps Planning	

Figure 3. Module 1 for general managers.

Pre-Program	Module II - HSE Managers								Post-Program
	Day 1 - HSE Culture		Day 2 - Shift in Role & Mindset		Day 3 - HSE Toolbox		Day 4 - HSE Toolbox		
Safety Leadership Book Reflection Questions on book Establish 12-Month HSE Strategic Plan and Heat map with GM Safety Survey	08:00-08:20	Why the HSE Program?	08:00-08:15	Reconnect	08:00-08:15	Reconnect	08:00-08:15	Reconnect	Plan Execution
	08:20-09:45	Bradley Curve, Program Roadmap	08:15-09:45	Understanding Our Challenges in Creating HSE Culture	08:15-09:45	Incident Learning Process	08:15-09:45	Introduction to Change institutionalizing program	
	15'	Break	15'	Break	15'	Break	15'	Break	
	10:00-11:00	Group discussion about Safety Leadership book	10:00-12:00	Best Practices in Driving Change	10:00-12:00	Incident Learning Process	10:00-11:20	Refine HSE Strategic Plan	
	11:00-12:00	HSE = Driving Discipline in the Business					11:20-12:00	Next Steps Planning	
	12:00-01:00	Lunch	12:00-01:00	Lunch	12:00-01:00	Lunch	12:00-01:00	Lunch	
	01:00-03:00	Introduce GMM Model - How does it relate to the plan? Work on Culture using GMM Model	01:00-03:00	Taking on the role of a Consultant to the Business	01:00-03:00	Employee Engagement - Harvesting Frustrations			
	15'	Break	15'	Break	15'	Break			
	03:15-04:00	Review & Refine HSE Strategic Plan	03:15-04:15	Statistical Data Analysis	03:15-03:45	HSE Paperless System			
	04:00-05:00	Case study – Culture shift in action			03:45-05:00	Creating HSE Point of View, Presentations and Feedback			

Figure 4. Module 2 for HSE managers.

enables the HSE managers to monitor, plan and improve safety more efficiently. This also supports the HSE point of view in business and therefore facilitates more change. The detailed design of the module 2 is presented in Figure 4.

4 DISCUSSION

Safety leadership is a key to safety culture transformation and safety performance improvement in organizations (Barling et al. 2002, Kapp 2012, Tappura et al. 2014, Tappura & Nenonen 2014). Managers have an essential role in implementing the safety policies and procedures of an organization (Griffin & Hu 2013, Hale et al. 2010). The traditional leadership facets of transactional and transformational leadership are suitable construct for safety leadership (Barling 2002, Clarke 2013, Kapp 2012, Tappura & Nenonen 2014). Thus, to be able to truly improve the safety performance of an organization the safety leadership behavior must be improved, and managers' leadership skills developed.

In this study, a concept for safety leadership training was constructed to develop safety leadership competencies of line managers and to improve the safety performance of the target company. The concept supports managers in enabling safety culture improvement in their facilities by developing their safety leadership competences, creating safety commitment, ownership and accountability across the organization (see Conchie et al. 2013).

The scientific contribution of this study is based on the novelty value of the concept. Until today, the literature does not provide a detailed training concept for developing safety leadership competences of managers. Additionally, the construction of the concept provides the basic requirements of training content and their preferable order to assure that the leaders are capable of leading a successful safety culture change of an organization (see Hale et al. 2010). Moreover, the results provide guidance for other organizations, managers and safety professionals towards developing safety leadership in various organizations.

In the future, the concept is utilized in the company globally to ensure a step-change in safety performance and a sustainable safety culture change in facilities that are struggling with their safety performance. Further research could proceed with more detailed analysis of the content of the concept and with the evaluation of the concept's success in other industries and scientific studies. The actual contribution of the different training contents of the concept to the enhanced leadership competencies of line managers could be further evaluated. In addition, the link between the transformational leadership competencies of managers and the success of the safety culture change could be further researched.

In the future, the construct of this concept could be adapted according to the current state of the facilities' safety culture. With this construct, the concept could provide more allocated tools to facilities according to their current state of safety culture and safety performance. For facilities that still have highly dependent culture, the concept could provide more concrete tools to improve safety performance while for interdependent cultures the concept could focus more on leadership competencies and employee engagement.

5 CONCLUSION

Safety leadership is vital in regard to the safety culture transformation and safety performance of the organizations. This study provided a training concept for future safety leaders to develop their safety leadership competencies as well as create commitment, owner-ship and accountability across the organization. The new concept harnesses the managers with concrete tools to improve the safety performance and safety culture of their facilities and provides information and support for leading successful change. The concept can be adapted according to the current state of safety culture in particular facility.

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Monitoring of lighting in a school classroom

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ABSTRACT: Sunlight has a positive effect on mental and physical well-being of people and its sufficiency can increase productivity of workers by 15%. Furthermore, it positively affects groups of people of all ages, especially children. On the contrary, its deficiency can cause sleep disturbances, increased stress level, obesity or fatigue. Therefore the lighting in classrooms and places of visual tasks for students must meet the minimum requirements of lighting limits. This article deals with the representative classroom in which measurements were taken throughout the whole teaching process with the involvement of both natural sunlight and artificial lighting fixtures. Obtained results were compared with values given by the technical standards and legislation. With a help of computer models that are being used in lighting design, there was a new lighting design of classrooms elaborated and the authors also considered all economic benefits of this proposal. There is a presumption that the implementation of this project will improve the well-being of students and thus their study performance. Good visual performance is a prerequisite for labour productivity with all the economic consequences.

Keywords: school environment; lighting; monitoring; comfort; student performance

1 INTRODUCTION

Importance of lighting, besides all the other requirements regarding everyday deployment of a building, should be taken into consideration in the process of creating project documentation and designing particular interior in all buildings. (Boyce 2003a). This supposition applies also to all school buildings and facilities (Mačurová & Pavúk 2007).

Lighting should be designed to provide people with the right visual conditions that help them perform visual tasks efficiently, safely and comfortably (Boyce 2003b). The luminous environment acts through a chain of mechanisms on human physiological and psychological factors which consequently influence human performance and productivity (Gligor 2004).

Suitable and sufficient lighting results in visual wellness. It can be defined as an optimal psycho-physiological state of organism stimulated by optical situation in outer environment that is needed for both efficient work and relax. (Gilbertová 2002)

On the other side, visual discomfort leads to an eye fatigue and thereby to possible sight damage and it also disturbs the overall human wellness, mood and productivity of a person. (Winterbotton 2009). It depends on the lighting of the area, objects and a workplace. The quality of lighting is conditioned by:

- sufficient amount of light energy
- its proper space and time division
- colour design of an area (Tureková 2014).

2 REQUIREMENTS FOR CLASSROOM LIGHTING

Places that are designated for educational purposes need to be illuminated by adequate amount of sunlight. Lack of natural light can be compensated by artificial sources to keep the required intensity of lighting during all activities that are performed in particular place. Among some basic types of electric sources of light belong e.g. fluorescent lamps in places with need for higher intensity of lighting (Mačurová & Pavúk 2007), gas-discharge lamps and LED diodes (Smola 2009). Artificial sources of light are constructed so that they can reach the colour as similar to the natural light as possible (Winterbotton & Wilkins 2009).

In the frame of this project there is a proposal regarding the natural light parameters in accordance with STN 73 0580-1 norm—sunlight standards for buildings (part 1 fundamental requirements). If, for any technical reasons, it is not possible to provide sufficient amount of sunlight, the overall light intensity can be reached by compounding sunlight and artificial source of light. (MZ SR 2007).

Quality of natural lighting in a room depends on the intensity of sunlight, neighbouring buildings, position and size of windows, cleanness of window glasses and their orientation in the context of cardinal points. Dim and dirty glasses can catch up to 40–50% of the overall amount of sunlight. The lighting conditions are also contingent on the colour of walls and ceiling (Škvařil 2004).

2.1 *Measuring method*

To judge the influence of lighting on the light wellness of students we decided to measure particular photometric quantities. We measured the intensity of lighting (illumination) that is expressed in lux. The luminous intensity (E) is defined as a quotient of luminous flux (ΔΦ) falling on the plane and the area (ΔS).

$$E = \frac{\Delta\Phi}{\Delta S} \qquad (1)$$

where E = luminous intensity; ΔΦ = luminous flux; ΔS = the area of fallen luminous flux.

Illumination of the plane gets smaller with increasing distance from the source of light. It is also dependent on the incidence angle. The plane on which the rays fall perpendicularly is illuminated the most (Baer 1994). If the rays are parallel with the plane the illumination equals zero. For the illumination by spot lighting photometric equation is in order:

$$E = \frac{1}{r^2} \cdot \cos\alpha \qquad (2)$$

where I = intensity; r = distance from the light source; α = incidence angle of the rays (Novotný 2007).

From the practical point of view, the most important photometric quantity is the illumination (Bear & Bell 1992).

2.2 *Description of experimental place*

There was relatively small classroom at UKF in Nitra chosen for our experiment. It is situated in the building of Faculty of Education, in the ground-floor at the department of Technology and Information Technologies. This classroom is regularly used for educational purposes with 24 seats for students and 1 for a teacher. In a distance of 15 meters, there is another building that can influence the intensity of sunlight in our experimental room (Figure 1).

The classroom was orientated to the north-west, for more details about the place see Table 1.

Particular measurement was performed by a light meter Testo 545 (Figure 2). It was extremely accurate measurement since the permissible deviation defined by producer was ±2% (according to DIN 5032, part 6).

Figure 1. A classroom where all measurements were done—position of windows and nearby building, arrangement of furniture.

Table 1. Characteristics of sunlight and artificial lighting system.

Description of the office place					
Walls		Ceiling		Floor	
Colour:	White	Colour:	White	Colour:	Light gray
Material:	Plaster	Material:	Plaster	Material:	PVC
State of surface:	Clean	State of surface:	Clean	State of surface:	Clean
Description of lighting system					
Natural lighting system:		2 windows 800 × 1100 mm			
Artificial lighting system:		4 pieces of lamps		Number of light sources in lamps: 4 pieces	
		Type of light sources:		TESLA, PHILIPS TL-D	
		Power input:		36 W	
		Position of light sources:		Regular, symmetric	

Figure 2. Apparatus Testo 545 that was used for lighting measurement.

2.3 *Measurement outcomes*

The lighting measurements were executed in March between 8.00–15.00. This included 8 measurements of sunlight, 8 measurements of compound lighting and 3 measurements of artificial lighting.

The aim of objectification was to detect the current state of a workplace. Illumination was measured within the net of 20 selected control points (STN EN 12464–1 2012.). Height of the datum plane was 0.85 m above the floor, distances between measuring points were 1 m and the outer points of the net were less than 1.5 m from the wall (Figure 3).

Other control points were distributed in regular distances so that they can adequately monitor the whole measured place, changes in lighting and also places with the highest and lowest intensity of lighting. External conditions were measured by anemometer (psychrometer) AN 340.

Measurement was executed in the same time, in the middle of a room, 85 above the floor (Table 2).

Average values of sunlight are shown in Figure 4. Maximum amount of sunlight in the classroom was reached at 11.00 (507.4 lx), values both in the morning and afternoon were notably lower (100–200 lx).

Compound measurement was executed in the same time (by turning all lamps in the classroom on) and in the same points of measurement. Average values of lighting during the day are shown in Figure 5. Used lighting system notably improved the lighting of a classroom.

The lowest values now reached approximately 1000 lx, what obviously fills lighting requirements (min. 500 lx) for school classrooms.

Three measurements of compound lighting were executed in March at 18.15. Every control point was measured three times. Average measurement values are shown in Table 3. Luminous flux was stabilized before every measurement started. The flux is considered to be stabilized when the measured lighting value does not show any systematic changes 3 times in a row within particular time interval. When talking about gas-discharge and fluorescent lamps the minimal period of time for stabilization of a luminous flux equals 20 minutes (ČSN 36 0011-3 2014).

Average value of illumination was set as an arithmetical average of all measured values of total (E_n) and graded horizontal illumination in the whole place or its part, or the compound illumination on datum plane (STN EN 13032-3 2009).

$$E = \frac{\sum_{i=1}^{n} E_n}{n} \qquad (3)$$

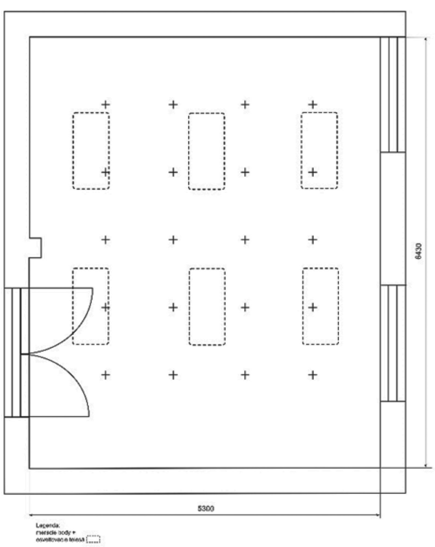


Figure 3. Distribution of measuring points (+).

Table 2. External measurement conditions.

Temperature °C	Humidity %	Temperature of wet thermometer °C	Condensation point °C
23.6	32.8	13.9	6.2

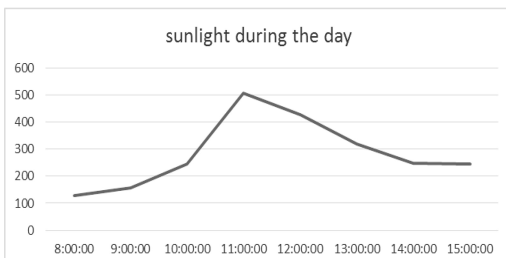


Figure 4. Average values of sunlight during the day.

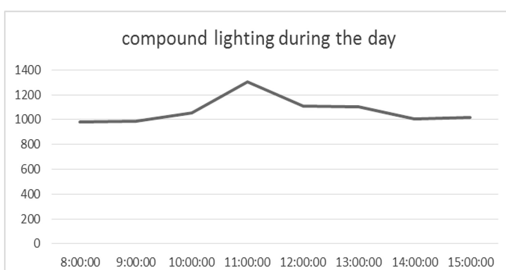


Figure 5. Average values of compound lighting during the day.

Other calculated values as the variance of measured values, the standard deviation etc. are stated in Table 4 (Rybár 2015).

Regularity of illumination under artificial lighting r was set as a ratio of minimal and average value of luminous intensity.

$$r = \frac{E_{\min}}{\bar{E}} \tag{4}$$

Parameter values of artificial lighting and measurement uncertainty are shown in Table 5. Uncertainty of measurement includes uncertainty of type A and type B that result from the attributes of measuring apparatus (n_B = ± 8%). The overall uncertainty was calculated according to Gauss' law of error propagation.

Notwithstanding the fact that compound and artificial lighting complied with required limit values, the progress in the area of illuminating systems brings new solutions that not only provide sufficient illumination of a workplace but also economic savings.

Model program DIALux was used for visualization of the place, it is so-called false colour rendering (Figure 6).

In the frame of this project we worked with the software DIALux that can be used for visualization of a classroom (Figure 7). We evaluated all pros and cons of already installed conventional fluorescent lighting and compared it with LED lighting system. The above-mentioned software also offers a possibility of choice from the bill of materials regarding lamps and lighting systems (DIALux).

Traditional fluorescent lighting does not have positive influence on human sight since it twinkles at higher frequencies what might cause an eye fatigue, headache or partial decrease in work efficiency. Proposed LED lighting does not have this negative effect and from the point of view of visual wellness it is more acceptable for human beings. The most important disadvantage of LED system is its higher price, on the other side it is a longer life-cycle that leads to consecutive economic benefits. In this particular case the payback period for the installation of LED panels

Table 5. Measurement outcomes under artificial lighting and limit values.

$\bar{E}$	U	$\bar{E}-U$	$\bar{E}+U$	E_{min}	r
lx	%	lx	lx	lx	
857.95	68.64	734.32	981.58	720	0,84
Required limit value of					
Luminous intensity lx			Regularity of illumination		
task	task surround		task	task surround	
500	**500**		**≥0.7**	**≥0.5**	

Table 3. Outcomes of average measured values of artificial lighting.

Point no.	Illumination lx	Point no.	Illumination lx
1	840	11	943
2	820	12	873
3	894	13	751
4	829	14	720
5	1003	15	852
6	1033	16	753
7	1057	17	790
8	999	18	767
9	825	19	786
10	894	20	730

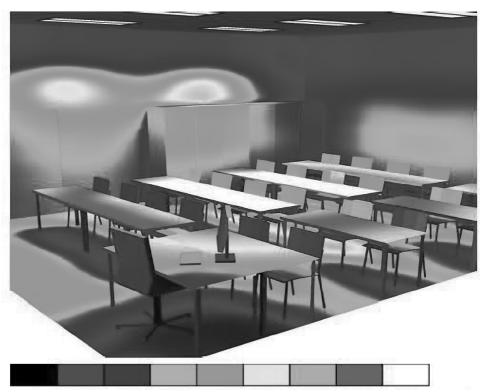
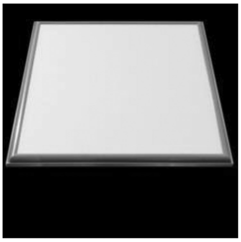


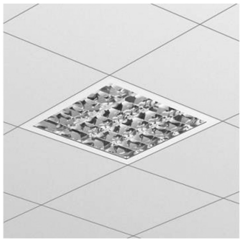
Figure 6. Rendering of place by false colours.

Table 4. Basic descriptive statistics of the file.

Mean	Standard error	Median	Mode	Standard deviation	Sample Variance	Kurtosis	Skewness	Range	Minimum	Maximum	Sum	Count
857.95	22.99307	834.5	894	102.8282	10573.63	–0.69237	0.600378	337	720	1057	51477	60



a)
V-Tac LED panel 45W, 600X600



b)
PHILIPS CR 200B 2xTL5-54 W

Figure 7. Comparison of the two lighting systems: a) proposed, b) existing one.

took 3 years and consequently the yearly power consumption dropped to half. Another advantage of LED system is that it is eco-friendly and just after activation it reaches full level of luminous flux (100%). On the contrary, the fluorescent lighting reaches 100% after some minutes.

3 DISCUSSION

Values of average illumination obtained by calculation were adjusted by an interval of extended uncertainty ±U and these were compared with requirements for lighting of rooms according to the type of place (STN EN 1246-1 2012).

To judge the accordance/divergence from legal requirements there is exactly defined set of definitions:

a. if the value of observed parameter (with interval of extended uncertainty (±U) reaches above required limit, this is considered to be a satisfactory state,
b. if the value (plus interval) is below required limit, this is considered to be unsatisfactory state,
c. if the value is above limit, but the bottom boundary of interval of extended uncertainty is below required limit, we cannot say that the state is satisfactory,
d. if the value is below the limit, but the upper boundary of interval of extended uncertainty is above the limit, we cannot say that the state is unsatisfactory.

When comparing the measurement outcomes with the limit values, we dare say that the current state in experimental classroom just under sunlight conditions is unsatisfactory. In case of compound and artificial lighting it is satisfactory and also regularity of illumination fulfils the limit requirements. When all particular control points that fall into the area of students´ activities are taken into consideration, the limit requirements are fulfilled.

To improve the overall illumination of the above-mentioned room, following measures can be applied:

– regular cleaning of lighting bodies according to the plan of maintenance,
– regular monitoring and change of defective lighting components,
– deployment of compound lighting, especially in winter months,
– correct usage of shielding technologies

In our experimental room we do recommend to change the current lighting system for LED lighting that might bring economic pros e.g. in the form of financial return within 3 years.

4 CONCLUSION

Based on the executed illumination measurements we state that the overall sunlight illumination in the experimental room was not sufficient at all. That is the reason why we must use compound lighting. This factor can cause visual discomfort, especially in cases of combination of other negative factors e.g. high temperature in summer months (there is no A/C system), or the lack of fresh air in the room. This all can lead to fatigue and lower level of students´ concentration on learning process. The light as such not only enables us to see, it also regulates our inner biological clock in the course of a day.

From the point of view of human health the adequate contact with sunlight on daily basis is more than important, otherwise so-called circadian rhythms can be interfered what leads to fatigue, insomnia, changes in metabolism, or even to enigmatic mood. (Illnerová 1989)

From the very beginning (the stage of elaborating the building project) is really needed not to underestimate the importance of sunlight illumination within the building, also taking an attribute of adequate distance from neighbouring built-up area into consideration. Another important organizational measure is the adequate and systematic cleaning of lighting bodies and windows.

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Biorhythm for injury prevention and safety awareness in VET: An Indian case study

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ABSTRACT: VET in India aims at development of skills through diversified courses. These courses are provided through Industrial Training Institute's (ITIs). Even though the emphasis was placed in the curriculum of ITIs on safety, injuries such as cuts, sprains, dislocations, burns and bruises are common.

The causes of these injuries are directly attributable to human errors. Traditional methods to reduce human errors assumes a constant level of human performance. Whereas, human performance is variable and often not a function of working environment. The theory of Biorhythms can predict human performance by means of understanding biological rhythms.

This study was conducted at ITI Latur of Maharashtra state in India. Where, theory of Biorhythms was applied to Mechanic Motor Vehicle (MMV) and Mechanic Tractor (MTR) trades to investigate its effect on the occurrence of injuries and on the basis of findings, it has been suggested that biorhythms may be an added dimension to safety awareness.

1 BACKGROUND

Vocational training programs in India are primarily managed by the Industrial Training Institutes (ITIs). A wide range of courses pertaining to different trades and vocations is being offered through a network of more than 11000 Government and Private Industrial Training Institutes (ITIs) located all over the country.

Skill training programs under ITIs have been designed to impart basic skills and knowledge in trades so as to prepare trainees as semi-skilled workers for wage employment as well as self employment.

About 70% of the training period is allotted to practical training and the rest to subjects relating to trade theory. A candidate who has attained the age of 14 years are eligible for admission in ITI.

All training courses operated by ITIs are administered under the Craftsmen Training Scheme (CTS). A wide range of courses pertaining to different trades and vocations having one or two years duration is provided through ITIs.

One Such ITI is situated in Latur of Maharashtra State in India. Where, the present study was conducted.

ITI Latur is imparting vocational training in various trades, including Automobile Sector Trades such as Mechanic Motor Vehicle (MMV) having course duration of Two years with four semesters, Diesel Mechanic (MDSL) of One year duration with Two semesters, Mechanic Tractor (MTR) having One year duration with two semesters. Each course has an intake of twenty trainees per unit. Every trade unit has an instructor who is responsible for imparting practical skills and knowledge by the use of tools machines and materials in the workshop.

Along with an Instructor the Group instructor ensures safety precautions in the workshop.

Even though the emphasis was placed in the curriculum on Theory and Practice of safety, minor to moderate injuries to trainees and instructors were reported frequently.

Occurrence of injuries may be due to the young age of trainees and also their Physical size, weight, skill, knowledge, inexperience becomes a factor for safety.

Measures for preventing injuries in ITIs includes education, skill training, protection devices, safety slogans, posters and verbal communication. No matter how much effort is made to create a training environment that is injury free, a low injury rate record can only be achieved by concentrating on the human element.

Need for developing a comprehensive safety solution to ITIs was the task before us. While exploring different options, some areas of research suggest that application of the theory of Biorhythm may create awareness to safety by predicting human performance through biological rhythms.

Hence, as a part of the ongoing research project, automobile trade of ITI Latur has chosen for study.

Through this paper the methodology and findings of the study conducted during 1st Aug. 2016 to 30th Nov. 2016 on two groups of trainees have been presented.

2 COVERAGE ON SAFETY IN SYLLABUS

Two Automobile sector trades with one unit each chosen for the present study. They are namely Mechanic Motor Vehicle (MMV) and Mechanic Tractor (MTR) each having twenty trainees.

One week, training schedule which includes 5 hours per week for classroom instructions and 27 hours per week for practical instructions has been allotted for safety training in the trade syllabus. Following topics related to safety are given in the curriculum

i. General precautions to be observed in the shop
ii. Basic first aid
iii. Safety signs—for Danger
iv. Warning, caution and personal safety message
v. Safe handling of fuel spillage
vi. Fire extinguishers used for different types of fire, safe disposal of toxic dust
vii. Safe handling and periodic testing of lifting equipment
viii. Authorization of moving and road testing vehicle
ix. Demo on first aid and fire safety
x. Use of fire extinguishers
xi. Electrical safety tips and interaction with fire service station
xii. Safety, disposal of used engine oil
xiii. Use of personal protective equipments

These contents on safety are allocated in the second week of training schedule. During subsequent syllabus coverage specific safety related theory and practice has not been assigned.

Under this circumstances safety awareness program during the whole of the training period is necessary. Biorhythm application can serve one of the measures for safety awareness. Hence, an attempt has been made through this study to develop safety solution for VET institution.

2.1 *Objective*

The cause of an injury to the trainees and instructors in the ITI Latur is found to be the human error. Human errors are due to mental, physical and emotional activities of the trainees and instructors fail to achieve their intended outcome. Existing methods to reduce human errors assume a constant level of human performance. However, human performance is a variable, Thuman (1977). Biorhythms can predict human performance by means of understanding biological rhythms, Brownley & Sandler (1977).

There are two objectives of this study

1. To investigate the effect of Biorhythms on the occurrence of injuries.
2. Examine the injury occurrence rate by briefing trainees in advance on their Biorhythms.

The aim of this study was to test the Biorhythm model as the predictors of injury prone trainees and a tool for safety awareness program for ITIs.

2.2 *Methods*

Two separate studies were conducted by collecting required data for the time period from 1st Aug. 2016 to 30th Nov. 2016 on the two groups of trainees. Group 1 have twenty trainees from Mechanic Motor Vehicle (MMV) trade, this group has not given their bio charts till the end of the study period. They were not aware of their Biorhythms. Usual and routine safety measures taken for this group. Self caused injuries during the study period along with individual Biorhythmic critical days has been recorded on an injury log sheet of MMV trade.

Group 2 having twenty trainees from Tractor Mechanic (MTR) trade. Correctly calculated Biorhythmic critical days along with bio charts was provided to them at the beginning of the study period. This group also briefed about the theory of Biorhythms and significance of critical days and bio charts. At the end of study period self caused injuries along with Biorhythmic critical days has been recorded on an injury log sheet of MTR trade.

For both the Groups Biorhythmic critical days were found with the help of free software available on internet, www.luckchart.com (2016).

2.3 *Procedure*

Basics of Biorhythm theory has been used for data analysis. The biorhythm theory postulates three biological cycles which begin at the moment of birth and continue throughout the life of every human, Thuman (1977). These cycles oscillate in a steady sine wave fashion throughout the life, Mohammadfam & Mahmodi (2013).

The basic rhythm, A, may be denoted by a sine wave with period T:

$$A = \sin\left[\frac{2\pi}{T}(t+\varphi)\right] \qquad \text{Thuman (1977)}$$

where $2\pi = 360°$; T = period in days; t = time in cycle days and φ = phase displacement.

The physical cycle 'P' has a period of 23 days, the emotional cycle 'S' has 28 days and Intellectual cycle 'I' has 33 days fixed natural biological rhythm, Newcomb (1971). Physical cycle affects physical strength, endurance, energy, resistance and physical confidence. The emotional cycle affects one's sensitivity, attitudes and irritability. Intellectual cycle, which affects memory functions and mental responses.

The critical days are suggested to be where, the cycles pass across the x-axis, Brownley & Sandler (1977). Critical days derives from the transition of the body from one phase to another. When this change occurs, the person is considered to be more unstable than usual and is thought to be increasingly likely to make mistakes, Brownley & Sandler (1977).

The data used in this study are those injuries taken place and recorded during 1st Aug. 2016 to 30th Nov. 2016 for the twenty trainees of Group 1 Mechanic Motor Vehicle (MMV) trade. Date of birth, date and time of injury and description of injury for each trainee was recorded and organized in tabular form. A free computer program which was available on the internet was used to identify critical days of each trainee. If date of injury coincides with physical, emotional or an intellectual critical day, then relationship between Biorhythmic criticality and occurrence of injury exists.

Similarly, in the case of Group 2 Mechanic Tractor (MTR) trade, Biorhythm physical, emotional and intellectual critical days with respect to their birth dates were identified at the beginning of the study. Individual bio charts were provided to each trainee. They were briefed about their critical days in advance and also during the study period. They were also asked to be more cautious during critical days to avoid injuries. At the end of study period injury occurrence for this group during study was recorded and verified with Biorhythm physical, emotional and intellectual critical days.

Table 1. Finding of the study.

Name of the trade	Number of trainees under study	Total reported injuries	Injuries on critical days and negative phase
Mechanic Motor Vehicle (MMV)	20	20	08
Tractor Mechanic (MTR)	20	12	02

3 RESULTS

This study investigated the relationship between the occurrence of injuries during four month study period with Biorhythmic critical day positions for the each trainee from both the groups.

The findings of the study are tabulated in Table-1 given below. Which show the effect of Biorhythm on MMV and MTR trade trainees.

Table 1 shows there was a significant relationship exists between the occurrence of injuries and criticality in case of Group 1 of MMV trade trainees. Eight trainees out of twenty have injuries on their Biorhythmic critical days or negative phase of Biorhythm cycle.

Whereas, in case of Group 2 of MTR trade trainees as they are aware of their Biorhythm critical days well in advance, 40% reduction in their injury rate was observed as compared to group 1 trainees. This reduction in injury rate might be because of awareness and alertness put by them on their Biorhythmic critical days.

4 DISCUSSION

The aim of this study was to establish relationship between biorhythm criticality and occurrence of injuries to trainees and applying Biorhythm model as a constructive tool for awareness to safety thereby preventing injuries of ITI trainees.

The findings of the present study confirm the findings of the study by Neil et al (1975). A twofold small-sample study, which involved, monitoring the academic performance of four graduate students. The second portion of the study involved a comparison of Physical biorhythm data with 66 lost time accidents. Findings revealed that good performance occurred most often in the positive phases and poor performance, including accidents, occurred most often in the negative phases.

Another study by Ezzatallah Baloni Jamkhaneh et al (2014) investigated the effect of the biorhythm cycles at the score level of students.

Similar experimental work done by Newcomb (1971) where he divided the workers into three groups. Group 1's Foreman warned his workers on correctly calculated critical days. Group 2's Foreman warned his group on Falsely calculated critical days. Group 3's foreman did not change or do anything different. It has found that group 1 decreases their accident rate by 58%. The Findings of the present study also show a 40% decrease in injuries sustained by trainees at ITI Latur.

Rohit Sharma et al (2011) in their work concluded that biorhythm critical days play a vital role in predicting the Industrial accidents.

Biorhythm research spreads across all disciplines, and occupations. Some researchers believe that the accident rate reduction, was caused by the Hawthorne effect. It refers to any situation where, the person knows he is getting special attention. This special attention tends to improve his performance.

4.1 *Limitations*

For the present study critical day has been considered for twenty four hours. It is because of the time of birth and place of birth of trainees was not known. To have an exact critical time computation, person's exact time of birth and place of birth needs to be required. Also, for a more meaningful study obtain a larger sample.

5 CONCLUSION

The findings of the present study show that any injury prevention program that cautions trainees of ITIs to be careful is likely to have beneficial results.

For the sample examined in this study, there exists a relationship between injury occurrences and biorhythmic criticality.

A safety oriented program in ITIs if continually brief trainees of their Biorhythms may, in fact, reduce injury rates during practical training.

Observations of the present study suggest that Biorhythms will act as an information system and can be implemented as a constructive tool for ITIs as a means to warn trainees, and make them more safety conscious during their critical days.

5.1 *Recommendations*

1. Encourage trainees of ITIs to think that all injuries are preventable
2. Trainees in ITIs are young, hence are more vulnerable. Therefore, introduction of biorhythm charting will enable them to develop preventive behavior and awareness of safety.
3. A biorhythm is not an only safety solution for ITIs. However, it should be used with other safety measures which are already in practice.
4. Instructors of ITIs should never leave trainees unattended while doing practices.
5. Educate trainees and instructors as to how biorhythm works and administration of ITIs shall circulate bio charts to all trainees and instructor for exercising extra caution on critical days.
6. Exclusive safety standards and regulations for ITIs required to be made.

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Complexity and safety: Multidisciplinarity and inter-stakeholder view

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Responses to institutional complexity associated with safety requirements in a large nuclear industry project

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ABSTRACT: Contemporary organizations are increasingly exposed to multiple institutional logics that prescribe differently what comprises acceptable goals and actions. The present study investigates responses to institutional complexity related to safety requirements in an international nuclear industry project. By adopting an in-depth inductive single case study, we approach a nuclear power plant project's organization as a project network. The findings reveal that multiple institutional logics co-exist in the project and in such a complex institutional setting the project actors draw on a broad response repertoire in an attempt to make sense of the change and craft an acceptable balance. Reconciling and aligning these different perceptions, logics and responses with a central focus on ensuring safety is one of the prevailing challenges from safety management and project governance perspectives.

1 INTRODUCTION

Institutions are social structures, composed of cultural-cognitive, normative, and regulative elements (Scott, 1995), which provide significance and stability to social life along with associated activities and resources. Institutional context comprises a set of institutional logics—guiding principles or socially constructed patterns of cultural symbols and practices, which provide meaning and orientation by prescribing means for interpreting and acting (Thornton et al., 2012). They provide formal and informal rules of action and interaction, related to the legitimacy of goals and achievement strategies. Organizations experience *institutional complexity* when they have to handle pluralistic demands arising from multiple institutional logics (Greenwood et al., 2011).

Projects that involve actors from different institutional environments are seen as "inter-institutional projects" (Dille & Söderlund, 2011). These projects are implemented under different regulations, norms and rules, and include various professional groups and multitude of cultural frameworks. In particular, nuclear industry projects are carried out in an institutional context, related to the host country where the future nuclear power plant will be located, national and international regulatory frameworks, project network and the global nuclear industry. In such projects, different prescriptions for decision-making and action are stemming from the multitude of goals, values, practices, competences and business models of project actors, as well as from different ways to achieve safety and manage the project. Stakeholders pursue their objectives through a variety of means, and complexity arises from the multiple interactions and interdependencies and the interpretations of these.

Dealing with plurality of demands in temporary organizations such as high-risk projects may generate tensions, which need to be handled so that safety is never compromised. The discussions following the Fukushima Daiichi accident also highlighted the importance of the institutional context, in particular the societal structures and systems, which contribute to safety in the nuclear industry, such as the specifics of regulatory framework and communication between different stakeholders (The National Diet of Japan, 2012).

In this paper, we aim to shed light on how key actors in a large nuclear industry project respond to institutional complexity. The specific focus of the study is the process of adoption and implementation of a novel method for handling safety requirements in the nuclear power plant project, which is executed in the context of prevailing multiple institutional logics. The key project actors are coming from different national institutional backgrounds and they need to find a way to resolve their differences and work effectively while ensuring safety and progress of the project at the same time. Recently, the process of adoption and implementation of innovative practices from a multiple institutional logics perspective have been explored in the healthcare sector (van den Broek et al., 2014). Still, to the best of our knowledge such a process has not been studied in an international nuclear industry project network context.

The research question of this study is '*what are the institutional logics and associated responses related to the process of adoption and implementation of a new method for safety requirements management in a large nuclear industry project?*'

The paper is organized as follows: first, we briefly introduce the relevant theoretical perspectives, comprising of institutional logics, safety requirements and complex projects; next, we present the method, followed by a summary of results and discussion section.

2 THEORETICAL PERSPECTIVES

2.1 *Institutional logics*

Institutional logics or demands can be seen as beliefs, systems and related practices that prevail in organizations (Scott, 1995). Institutional logics are powerful because they ground the legitimacy of organizational practices (Greenwood et al., 2010). Previous literature indicates institutional logics affect organizational action by structuring the limited attention of social actors (Thornton & Ocasio, 2008). Basically, actors are culturally embedded in dominant institutional logics: the dominant logics affect what is paid attention to in organizations, what is ignored and what are the acceptable organizational solutions. Therefore, it is likely that organizational decisions reinforce the prevailing institutional logics (Thornton, 2002; Greenwood et al., 2010; 2011). It means that when different stakeholders are influenced by different logics, adoption and implementation of new approaches and practices in organizations could result in possible tensions, contradictions and ambiguities (van den Broek et al., 2014).

In recent studies on organizational responses to competing institutional logics, Pache & Santos (2013) described the process of adopting selective coupling or hybridization patterns that select elements from different logics as a strategy for gaining legitimacy, survival and growth. Studies in safety-critical domains explored management of the pressure from multiple institutional demands. For example, in the health care sector, market mechanisms were found to be shaping the shift from a professional logic dominance to a managerial logic dominance (Scott et al., 2000). Reay & Hinings (2009) studied a Canadian health care system and indicated that both professional and business-like logics co-exist, with doctors and nurses acting in accordance with a professional logic that emphasizes the quality of care, while managers and directors might take on a more business-like logic, which is mainly occupied with efficiency.

2.2 *Safety requirements*

Safety requirements are a focal point in safety-critical industries, such as nuclear power production, aviation, healthcare, oil & gas, mining industry. Organizations in these industries must elaborate and satisfy a vast number of safety requirements in order to get legitimacy. Importantly, they need to do this continuously throughout their lifecycle to ensure safety.

Institutional complexity associated with safety requirements relate to the need for nuclear industry organizations, both new builds and operational utilities, to adhere to multitude of requirements, including safety and quality standards, rules, regulations, and commercial contracts that aim at ensuring high level of safety for protecting people and the environment from harmful effects of ionizing radiation. Due to possibility for catastrophic consequences, the safety requirements for the nuclear power industry are among the strictest. International institutions, which are promoting the highest levels of safety and developing safety requirements and guidelines for the nuclear industry are the International Atomic Energy Agency (IAEA), World Association of Nuclear Operators (WANO), and the Institute of Nuclear Power Operations (INPO).

The IAEA has developed a set of Safety Requirements, which must be met to "ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework." (IAEA, 2017). This postulates that national requirements, for example, those issued by national regulatory bodies, are in line or "nested" within international requirements. However, in international safety-critical projects, the Supplier and contractors often need to satisfy both the requirements of their home country and the ones in the host country. The agreements and requirements in the commercial contracts between project actors need to be strictly followed, as well as the international quality and other relevant industrial standards.

Consequently, nuclear industry organizations have to conform to a large number of rules and requirements to develop and maintain the required level of safety throughout their lifecycle. Although the overall goal is to ensure and improve safety, these rules and regulations derive from different institutional logics and may not be easily interpreted or fully harmonized. The need to advance our understanding about the ways in which organizations respond to multiple institutional logics was identified in the literature (e.g. Greenwood et al., 2011; Lounsbury, 2007).

2.3 *Complex projects*

The institutional perspective maintains that projects encounter pressures from their institutional environment and—in order to survive—must adapt to and be rooted in the environment, i.e. be knowledgeable of the environments' rules, traditions, practices, norms, values and procedures taken-for-granted in the organization (Meyer & Rowan, 1977) – otherwise conflicts may arise (Miller & Lessard, 2001; Orr & Scott, 2008). International projects that bring together a set of multiple organizations face a variety of mixed institutional pressures and conflicting demands from their host country environments, participating project actors, stakeholders and parent organizations, which they need to make sense of, carefully balance and respond to (Aaltonen & Sivonen, 2009). Earlier research on institutional differences in international projects has particularly focused on inter-firm collaboration between a host organization from a developed country and a local organization (Orr & Scott, 2008). Navigating in complex institutional environments with multiple institutional logics requires distinctive knowledge and capabilities and has proved to be highly challenging in practice, resulting in struggles that may potentially deteriorate project performance and endanger its survival (Javernick-Will & Scott, 2010).

Although projects are temporary endeavors since they have a beginning and an end, this does not mean they are short-term: especially nuclear industry projects are long-term endeavours, which implies they experience long-term exposure to different institutional logics throughout their lifecycle. This specific feature sets additional challenges for continuously developing and maintaining safety excellence while balancing with other important project goals, such as schedule and costs.

3 METHOD

The empirical phenomenon and practical challenge studied in this paper is the adoption and implementation of a novel method for managing safety requirements nuclear industry project. We adopted an in-depth inductive single case study method (Yin, 2008) to reveal the project actors' responses to institutional complexity. We examined the narrative views of project actors about this event, by which they construct meaning.

The project network includes various organizations including the project owner, the plant supplier, the main contractor of the plant supplier and other sub-suppliers and subcontractors. The owner has a turkey contract with the plant supplier. The main contractors are experienced in the nuclear field, based on which documentation for fulfilling the safety requirements has been proposed. However, it turned out that this approach is insufficient, which led to introduction and implementation of a new safety requirements management method for nuclear facilities. The implementation of the method was still ongoing at the time of the data collection allowing us to capture data on perceptions and responses to this change in real time. The novel method has been developed by another power company, which has successfully utilized it for managing safety requirements in a different nuclear facility, which meets the regulatory requirements for nuclear safety.

We carried out eleven semi-structured interviews in October-November 2016. The interviewees were suggested by the owner company, and they were from different organizational units and hierarchical levels; most of them were at management level and had experience in the nuclear field. The interview themes were related to the overall organizing and coordination of the project network, to the introduction of the new method and to the experiences that the organizations received from it. The interviewees' own stories and perceptions concerning the change were encouraged. All data were content analyzed by first identifying the relevant themes and indicators that emerged from the data with regard to the introduction of the new method. After this, a second coding round was carried out during which different storylines and interviewees' interpretations concerning the new method started forming. During this stage, the researchers discussed and shared their thoughts on the indicators in different storylines and combined similar themes together. As a result, a set of institutional logics and associated responses emerged, each stemming from narrating differently the rationale for implementing the new method.

4 RESULTS

We found that project actors' responses to institutional complexity are compatible with a specific configuration of emerging institutional logics we identified in the process of adoption and implementation of the novel method in the ongoing project. These logics are summarized as follows:

– *Local safety logic* (stemming from project actors' current or previous successful experience with what works in terms of ensuring safety in their home country)
– *Project management/control logic* (focus on efficiency and control on the adoption and implementation process from a project management perspective)
– *Legitimization logic* (related to the need to indicate full and accurate fulfilment of safety requirements and to secure documentation approval by the national regulatory body as an important institution)
– *Commercial or business logic* (stemming from the contract relationships in the project and the need to adhere to legal and commercial agreements between project parties)
– *Engineering logic* (postulates the new method as a necessary technical tool to manage the strict safety requirements in a structured way that provides transparency and traceability from an engineering perspective)
– *Project relationships logic, including cross-cultural interaction* (emphasized the development of trust and relationships in the project and the need to facilitate the collective knowledge sharing among the actors by using the new method)
– *Capability development logic* (the recognized need for project actors to learn new skills and competences, and to make tacit knowledge explicit)
– *Protection logic* (stemming from the need to protect established, proven practices and ways of working and reflecting the time needed to handle the uncertainty and ambiguity triggered by the change in the project).

In terms of power dynamics, the identified logics can be classified in three groups of responses as *driving* (the project management/control, legitimization, local safety logic and commercial/business logic), *conservative* (protection logic) and *balancing or bridge-building* (professional engineering logic, project relationships and capability development logic). Some implications are discussed in the next chapter.

5 DISCUSSION

Nuclear industry projects are inherently complex as they are facing the need to balance between different tensions such as safety and efficiency or production, short-term goals and long-term goals. Our findings indicated that in such a complex institutional environment the responses repertoire of the project actors is stretched: they produced a wide range of responses in an attempt to craft an acceptable balance with a central focus on ensuring safety.

Faced with the plurality of different institutional logics in the process of adoption and implementation of the novel safety requirements management method, project actors seem to react by making sense based on their professional identities, previous work experience in the nuclear industry and in international projects, and national cultural features.

The new innovation-induced logic prescribed by the adopted method stretches also the prevailing conservatism in the nuclear industry and forces project actors to reconstruct their views in favor of the new logic, which emphasizes transparency and traceability for management of requirements and achieving high level of safety. While traceability aims at ensuring that the outcomes comply with specific rules or requirements, transparency requires openness and communication.

We suggest that certain institutional preconditions need to be at place to allow and further nourish this balance between traceability and transparency. More specifically, the *driving* and *conservative* institutional logics need to be harmonized with the *balancing* institutional logics. As our findings indicate, the driving and conservative logics seem to be prevailing over the bridge-building logics, which opens new opportunities for management of safety and development of alignment strategies in nuclear industry projects based on recent developments in governance in complex project networks.

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Some results of a modern approach to the occupational safety and health problems

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ABSTRACT: European Directives on OS&H recommend a systematic Risk Analysis of the working activities, whose results should be discussed in some formalized documents. If we consider the Italian situation, at least as resulting from in depth analyses of a number of fatal accidents, the main risk analysis techniques adopted appear based on multi-purpose precompiled forms and Risk matrices deriving from subjective and incomplete assumptions. This is due to a merely formal implementation, heritage of an obsolete prescriptive approach. Hence, the need of a strong contribution to the wide spreading of a Culture of Safety based on study and research in the field of OS&H. Our OS&H research group of Politecnico di Torino, developed and is still working on a well-tested approach covering all phases of Occupational Risk Assessment and Management. The paper deals with some innovative results on Accident Prevention and definition of workers' exposure models in a System Quality approach.

1 INTRODUCTION

Over one million work-related deaths occur annually according to International Labour Organization—ILO estimates, and hundreds of millions of workers suffer from workplace accidents and occupational exposure to hazardous substances worldwide. Unfortunately, the Italian scenario follows the dramatic world trend: in 2014, about 500 fatalities and 330000 severe injuries occurred involving more than three lost days (EUROSTAT source). The economic costs of work-related injuries and diseases are rapidly increasing. The ILO experts say that approximately the 4% of the world's Gross Domestic Product—GDP disappears with the cost of diseases through absences from work, sickness treatment, disability and survivor benefits. These numbers confirm a general degenerative state difficult to face, whose root causes are different in terms of social and economic peculiarities of each Country.

The constant cultural change hardly gained at European level thanks to the issuing of 89/391 and 89/392 European Directives at the end of the '80 s, enforced by Italian Safety reference regulation, provided a gradual and progressive transformation of the approach to Safety and Health at work. The leaving of the rigid prescriptive approach of the '50 s based on formal compliance with the legislation on workers' protection, to a proactive approach should ensure both formal and substantial compliance to the new safety level required in the light of the Safety System rearrangement. Such an approach implies at first the definition of new roles and responsibilities for not only Governance aspects but, also including special assignments for OS&H, taking into account the maximum Safety technologically and epidemiologically achievable conditions.

Despite regulatory efforts, the problem of occupational injuries and health impairment remains a challenging task for policy makers, practitioners and researchers. This requires a nuanced understanding of the how and the why accidents and injuries still recur. The reasons of the problem are due to three main aspects:

- *fast pace of technological innovation vs embedded safety approaches*: the lessons learnt from accidents become ineffective when the old technologies are replaced from new ones. This scenario involves the introduction of different accident patterns also due to unforeseen events sometimes deriving from new Hazard Factors that if not correctly detected, become impossible to manage. In many cases, the common approaches still inspired by subjective judgement and general or personal experience are not in line with the research results essential to deal with the special criticalities of modern industrial and construction activities;
- *current safety management models*: the various forms of complexity and coupling characterizing modern systems affect the design and operational safety conditions: they make it difficult for designers to foresee all potential states of the

system and for the operators to handle safely both routine and exceptional circumstances. The current situation is much worse if we take into account the progressive increase of Risk Assessment and Management documents conducted by external independent consultants, particularly in Italy (EU-OSHA data). This does not question the quality of these documents but it confirms a tendency of enterprises to do "safety for the system out of the system", losing efficiency in short—term decision making.

- *poor dissemination of culture of safety:* according to ILO data, in countries at all levels of development, "a large proportion of the deaths and injuries by workers can be attributed to inadequate safety and health information". Safety rules, procedures and best practices are often written in the belief that greater control of workers' behavior will not only lead to a safer workplace, but also act as a buffer against prosecution in the case of accident. This paper-based safety spreads the passive role of workers, denying the risk awareness at the basis of safety performances of a system.

Coherently, the results of theoretical and applied research and study in the field of OS&H become an essential reference for an effective Prevention of work related accidents and health impairments. A shared line of thinking, which has been useful in this regard, involves those studies that suggest that our understanding of how accidents are caused (and therefore how they can be prevented) has evolved over different five ages (e.g. Borys et al. 2009; Hale A. R. et al. 1998). In this context, and in particular on advanced approaches, the group of OS&H of Politecnico di Torino, a research university and a leading institution to study engineering and architecture, operates in strict collaboration with the experts in Occupational Medicine of the Università di Torino. The common target is the development of research activities within the project "The General Safety Issues and Goals in Turin Universities—TGSIGTU" coordinated by the author L. Maida, based on the principia defined in the shared PoliTo-UniTo Guideline for the Occupational Risk Assessment and Management. The following paragraphs focus on the principal topics covering socio-technical and cultural issues, setting the basis for new studies on refined approaches nowadays in progress.

2 GENERAL SAFETY APPROACH ADOPTED BY POLITO

Managing Safety at workplaces turns out to be a particularly difficult task in the light of the new European Directives, which express the importance of a safety approach based on Risk Analysis covering all steps of the process, from Strategy definition to Risk Management in a System Quality Management. To reach this target, the main aspect to ensure is the Risk quantification (Table 1) deriving from a formalized, rigorous and exhaustive Hazard Identification:

The common sense before the law makes it clear the need to face OS&H criticalities in hierarchical order for more effective management of both human and economic resources. Unfortunately, the widespread use of qualitative techniques (including some risk matrices typologies) for Risk Assessment makes way for the analyst's subjectivity by

Table 1. Risk quantification approach.

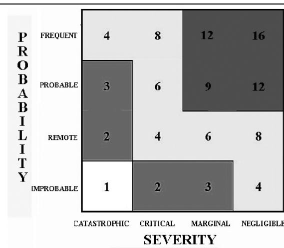
Risk = predictable damage due to the event M * expected frequency of occurrence P

If up to date technical standards and references are available, we can write: **M = ED * FC**

where:
ED = seriousness of the possible damage (death, injuries and health impairments, etc.);
FC = interference (or contact factor) is function of the percentile exposure time to potentially hazardous operations or situations compared to the working cycle;

Then: **RISK = ED*FC*P**

Table 2. Potential criticalities of a qualitative approach.



1. the same risk values can derive from combinations of M and P value, barely perceptible subjectively for hierarchical interventions;
2. the analysis' quality depends on the representativeness of input data;
3. if the input data are not reliable (or subjective) the results have arbitrary nature
4. ED is independent from the preliminary analysis of the General Support Services[1] - GSS: hence we cannot use as reference the Worst Credible Case[2]- WCC;
5. FC is not considered in the analysis: related over/underestimation of risk can affect the whole analysis
6. If more than 1 worker is exposed to the Hazard Factor, neglecting this circumstance can produce an incorrect Risk Assessment

[1]GSS represent the technical and organizational answer to criticalities according to general and specific regulations.
[2]The WCC is the most severe accident considered plausible or reasonably believable.

Table 3. Level of expected frequency of occurrence approach.

- ED is expressed e.g. in terms of lost days according to Italian standard UNI 7249/2007 (work related accident statistics—injury frequency/severity rates), and law D.M.12/07/2000 (dispositions for worker's disability insurance);
- FC can be estimated in% of the exposure to the Hazard Factors during the work shift;
- Also P, i.e. the possibility of deviation from the correct work organization/development, can be numerically evaluated: stated that the minimum probability of occurrence of hazardous events obviously corresponds to a situation coherent with up to date technical safety standards, a simplified and effective approach to the evaluation of P can be based on the use of the expected frequency of occurrence level, written as:

$$PR = \frac{\text{expected frequency of occurrence of the event (present situation)}}{\text{minimum expected frequency of occurrence in compliance to up to date safety standards}} \quad \begin{array}{l} \leq 1 \text{ correct situation;} \\ > 1 \text{ unacceptable situation} \end{array}$$

influencing the outcome of the analysis. Moreover, the common lack of information on the used Risk Assessment criteria in the Safety documents affects the repeatability of the analysis also in term of reorganizations of safety tasks in the System. A qualitative approach may give misleading results (Table 2):

Influenced by approach suggested by the Group ad Hoc—European Commission (1996), the introduction of *the level of expected frequency of occurrence* of deviations makes it possible a rigorous analysis in compliance with up to date safety regulations taking into account epidemiological and technical progress. A numerical risk evaluation unbiased by subjective estimation is then possible (Table 3)

The approach provides an adequate evaluation of the possible severity of event's consequences, since in a situation accomplishing to the regulatory requirements there will not be any worsening in consequences due to other flaws (mainly in GSS: e.g. communication system, fire-fighting systems, organization of first aid, etc.). This way of thinking can be applied as general reference for Occupational Risk Assessment and Management covering different NACE sectors (i.e. manufacturing, construction sites, etc.) and in special contexts also (Borchiellini et al. 2015). The method provides a careful and systematic approach to OS&H issues considering the continuous technical and epidemiological evolutions which can be of good reference to verify the final results by different approaches.

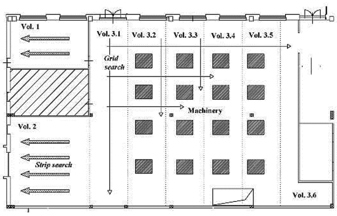
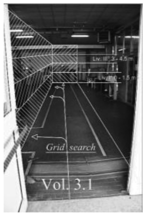
3 FORENSIC TECHNIQUES APPLIED TO OS&H ISSUES

An effective definition of the exposure models for each worker involved in the system depends firstly on a correct Hazard Identification: obviously, in the case of undetected or underestimated (e.g. general dust vs dust with high silica content) Hazard Factors, the analysis results in an incomplete Risk Analysis misleading the Risk Assessment and Management phases. In context characterized by socio economic changes, the lack of a rigorous approach transferable between the "old and new" OS&H resources refers at the analyst's experience in the whole process of Risk Analysis. Hence, the completeness and comprehensiveness of the results depend strongly on the analyst's level of knowledge of the system. The need for a formalized analysis, regardless to subjectivity of judgement, has led our research group to explore the possibility of an original application of investigative techniques typical of forensic sciences. The only method for an exhaustive Hazard Identification is a thorough investigation of the environmental and technological unit based on real evidences for shell, services and interior spaces of settlements containing workplaces and their not-operative aspects. This approach allows to reach two different safety levels depending on whether it relates to: a) structures and facilities under construction or recent, b) structures and facilities outdated with high historical/architectural value (Borchiellini et al. 2016).

A careful focus on main forensic investigations techniques reveals a fundamental difference between the proposed techniques: in particular, some suggest functional volumes discretization methods, while others provide guidance on how investigation should be performed. In the context of OS&H, special combination of volume discretization and way of looking-for techniques could contribute to achieve an exhaustive workplace general safety analysis, taking advantage of the most useful peculiarities of each technique. Table 4 summarizes the results of a test in a workshop of Politecnico di Torino.

The practical tests of the method in different environmental units provided some suggestions on the most suitable Canvassing technique for different scenarios, with reference to both main logistic and operative parameters that can condition the selection. The completeness and repeatability of such an approach, still under development for particular contexts, become a good reference for a thorough investigation of working environments.

Table 4. An example of test results.

Site: **WORKSHOP**	
	
The method at a glance	
	
Workshop discretization	*Layout of a workshop*

It makes also possible to derive checklists on the state of conservation of the achieved Safety level over the time, which can be carried out by not particularly expert operators (in the case of the Politecnico di Torino typically the safety advisors headed by the various Departments and Units).

3 AN EFFECTIVE APPROACH FOR THE WORKERS' EXPOSURE MODELS DEFINITION

The protection of Safety and Health of workers requires the definition of exposure models based on the quantification of Hazard Factors: the processing of the measurement results is strictly linked to ensure:

- ***1st level of representativeness***: a careful and well-planned quantification of specific factors resulting in data (measuring process results) that accurately represent the actual working scenario. This target can be achieved only ensuring all the activities aimed to ensure: a) the representativeness of the analytical results of the measured parameters, b) the equipment management, c) the preliminary activities necessary to confirm the equipment adequacy to the intended use. A pivotal aspect concerns the suitability of the measuring equipment resulting from a metrological confirmation process, in order to ensure both maximum "data accuracy", and economic sustainability (Bisio et al. 2016);
- ***2nd level of representativeness***: a suitable data processing, aimed to ensure the usability of the measurement results in terms of outliers presence, belonging statistical distribution, and statistical representativeness of samples. Such an approach makes it possible to compare the exposure data with the Safety regulations, standards and good practices, focused on the accidents and health impairments prevention on a statistical basis (Bisio et al. 2017, in press).

Over many years, our research group deal with Occupational Risk Assessment in case of airborne pollutants (dust, fibers, etc.). In this regard, an approach has been implemented: Figure 1 and Table 5 summarize the development of the method providing special focuses on measurement equip-

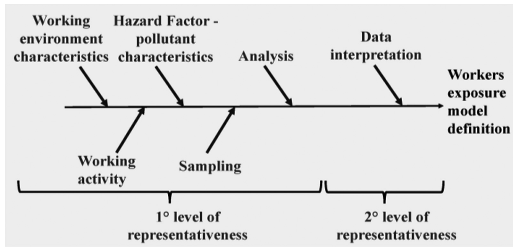
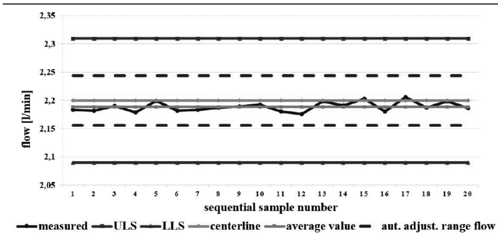
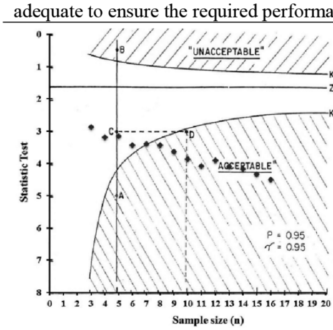


Figure 1. Workers' exposure model definition Ishikawa diagram.

Table 5. Examples of parameter monitoring and representativeness test.

	
Measuring equipment management: sampler airflow monitoring	
As shown in the control chart, the flowrate variability is lower than the variability allowed by specifications (± 5%). The flowrate statistical control provides the metrological confirmation of the sampler: hence the sampler results adequate to ensure the required performances.	
 *OTL-Tuggle results*	Statistic Test trend vs the increasing sample size on the reference chart. It allows decision making on technical, organizational and procedural measures on the base of workplaces' conditions (acceptable-unacceptable areas)

ment management and statistical representativeness test results.

The research work is still in progress with the aim to verify:

1. the real effectiveness to identify the presence of airborne pollutants and their aerodispersion tendency by means of stationary samplings;
2. the accuracy of the assumptions concerning the workers' homogeneous groups in terms of exposure models by personal samplings.

4 THE COMPUTER—AIDED CAUSE CONSEQUENCE FOR PREVENTION—CCCP: LEARNING FROM ACCIDENTS

The work related accidents analysis shows a wide range of variables difficult to handle, depending firstly on the typology of the approach. The most used approaches are based on a large data collection organized into macro areas (typically NACE sectors), for considerable time spans (3 or more years), show significant criticalities in the practical use.

The difficulties to reach representative results on occupational accidents trends are firstly due to the lack of an unambiguous record procedure, which, in the case of a huge quantity of data, involves the handling of a minimum number of several tens or hundreds of information for each event. In addition, a correct analysis of a single accident requires at least the record of general and specific information, the latter characterizing the event in terms of general and specific activity, severity and consequences, etc., taking into account the technical/technological and organizational specificities of the context in which it occurred, to make comparisons with similar occurrences. Thanks to the analysis on a number fatal accidents occurred in critical NACE sectors, carried out for the Prosecutor, the Authors developed an original approach based on a post event investigation to identify the correlation between the intermediate and root causes that led to unwanted events (Demichela et al. 2011). Over the years, after retrospective studies, including test on suitability of Hazard Identification techniques for accident scenarios, our research group developed the Computer—aided Cause Consequence for Prevention—CCCP technique, an original coupling of Event Tree Analysis—ETA and Fault Tree Analysis—FTA, implemented with a computer—assisted system (e.g. Luzzi et al. 2015). The focusing on a limited number of real events used as case histories and characterized by exhaustive and detailed information made possible an in depth analyses, upon which it became possible both to identify the real causes of the events, and to draw effective Prevention measures, since "daughters" of a tailored Risk Assessment and Management.

The peculiarity of the technique is the capability of modeling the system both in backward and in forward sense (Tables 6 and 7):

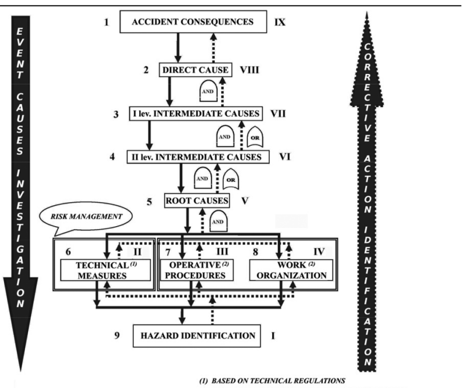
A – top-down 1 ⇨ 9: starting from the unwanted event and following a chain of Intermediate Events in order to identify the Root Causes—FTA approach;

B – bottom-up I ⇨ IX: starting from the Root Causes—identified in the previous step—it's possible to identify and discuss the most suitable prevention measures to break the chain of intermediate causes leading to the accident—ETA approach.

Tables 6 and 7 show respectively the approach of the model and an application on an injury occurred during a maintenance operation involving a Mobile Elevating Working Platform (Cirio et al. 2016).

The strength of the model allows performing a systematic analysis (according to the Reason's approach (Reason 2000)) consistent with up-to-date reference technical standards, and lead the analyst into the breakdown of the problem avoiding partial or distorted conclusions.

Table 6. Logic flow and characteristics of the model.



✓ each series of events, developed in the form of causal events list, is grouped into categories of sequential reference, to proceed along the tree until the initiators events;

✓ the n° of categories of intermediate events adopted was defined by experiments conducted on real cases: the scheme proposed can be used as reference for events occurred in industrial and constructions site contexts;

✓ the events in the chain (initiators included), belong to predefined categories, eliminating the possibility of arbitrary use of definitions and synonyms from the analyst.

Table 7. Example of CCCP approach application.

The MEWP lost stability due to incorrect operation exceeding the maximum lateral manual force.
The MEWP basis - positioned without preliminary analysis- skidded on cobblestones and got stuck against a building wall. A progressive deformation of the column on the opposite brick fence reduced the falling velocity of the platform and the operator survived by clinging to an orange tree.

results of the MEPW collapse

Accident causes chain		
1	Operator injuries	
2	Platform falling trajectory	
3	MEWP lose stability and fall beginning, stabilizers stuck against a wall, started the structure deformation	
4	Sudden failure of an element of the gutter	
5	Incorrect operator behavior, involving lateral forces exceeding the machine stability limits	
RM	Poor Risk Management	
	6	Incomplete on board signs - manual not clear and exhaustive
	7	Incorrect work procedures – careless positioning of the MEWP
	8	stabilizers Improvised organization: no 2nd operator, no supervision
9	Non exhaustive hazard identification leading to poor risk assessment (PR > 1)	

Possible corrective actions		
Correct use of the safety belt		IX
n.a.		VIII
n.a.		VII
See I & RM		VI
Monitoring the effectiveness of the training courses (ex Italian OS&H law D.Lgs 81/08 art.73,c.5)		V
Resulting from II, III & IV		RM
Careful evaluation of the machine stabilizers positioning vs pavement characteristics	IV	
Responsibilities definition and supervising	III	
Revision of the MEWP safety (possible incorrect EC labelling is under discussion)	II	
Even if not officially required by the Italian OS&H law, some Risk Analysis and Management of yards involving the MEWPs use is obviously necessary		I

5 CULTURE OF SAFETY: THE ROLE IN RISK ASSESSMENT AND MANAGEMENT

Working on OS&H issues means not only solve criticalities but also understanding how to spread the importance to work in safely conditions, and instill a general safety awareness among workers. Organizations have a fundamental role in promoting and communicating safety: to reach these targets collaborative interactions that help to disseminate a strong Culture of Safety are necessary among all actors at all levels of the Organization.

Our research group takes care to this aspect and thanks to the encouragement and support of Politecnico di Torino, is working on research activities with the aim of the dissemination of the Culture of Safety in different contexts but with a common target.

Obviously, the basic safety concepts are present in every field of engineering, since essential for a correct engineering design. Even if the Universities are obviously the "temples of advanced culture and technique", the conscience on the OS&H aspects appears often to be at a lower level, and some even elementary safety rules are sometimes considered a nuisance interfering with the research work.

The various activities (educational, research, routine test, production, etc.) characterizing Universities requires special approach in terms of Information Formation and Training—IFT for different figures involved as professors, administrative personnel, technicians, research fellows, students, visitors, etc. starting from Line and Staff roles. In this regard, our research group developed and is still working on a project proposal for "formation towards the zeroing of risks". This project was born with the aim to introduce basic OS&H concepts as starting point to achieve a common background level among the whole personnel.

The setting up in a "matrioska" structure allows developing three level of detail:

- *basic OS&H information*: this level introduces a common glossary of safety (terms, signs, labels, symbols) and provides elementary knowledge to recognize/identify hazards and potential risk associated including also general procedures for emergencies and safety ethics and responsibilities. This information are useful to all staff, and especially for new students' orientation;
- *specific OS&H programs*: this level makes it possible a flow of competences to improve working conditions and the awareness of the importance of a safe work. This is also the case of innovative laboratories where workers (with different roles and skills) carry out experimental and advanced research, also with machinery specially designed and constructed for research purposes for temporary use, excluded from the scope of Directive 2006/42/EC. The presence, among the Universities teaching and research staff of resources qualified on OS&H aspects should not be underestimated: their deep knowledge

Figure 2. Driven job safety analysis in a workshop.

of the local situation can be, in fact, a precious help in both the Occupational Risk Assessment and Management for complex problems and in organization of IFT actions. An appreciable experience focused on a driven simulation of a Job Safety Analysis for workshop operations (Fig. 2): it gave positive results because it fits into real applicability making the worker an active figure in the operation by involving him in the discussion in order to find a compromise between safety and operative requirements.

- *advanced OS&H Topics*: this section provides an open access of scientific publications with high level of deepening for those interested in finding out more about particular OS&H issues. Our research groups organized also some Conferences on Risk Assessment and Management in underground construction sites (De Cillis et al. 2015) and on the dissemination of Culture of Safety, the latter an international meeting supported by TELT sas—Tunnel Euralpin Lyon Turin (held in Turin, May, 12th, 2017 about "the basic role of the purchasers of great infrastructural operations in the promotion of the Culture of Safety").

This project is still under development but can be considered a starting point for the improving of OS&H conditions in the University.

6 CONCLUSION

The results of research activities within the project "The General Safety Issues and Goals in Turin Universities—TGSIGTU" confirm a real and an effective applicability of the method that can be useful as a reference approach to OS&H issues. The repeatability and the formalization of the general method provide an effective tool for Risk Assessment and Management in a Quality view, ensuring a continuous improvement and revision of the System. Some works in progress will increase the number of sub-applications of the shared PoliTo—UniTo Guideline widening the scientific research to challenging tasks, as the exploration and the investigation of new Safety Management Approaches—SMA.

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Situation and factors of aggressive behavior against railway station staff in Japan surveyed through passengers' perceptions

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ABSTRACT: Aggressive behavior against staffs has been a problem in public transportation. It is important to find out controllable influencing factors of the aggressive behavior to reduce the harm to staffs. In the railway stations, the passengers sometimes witness other passengers' aggressive behavior against the station staff. Therefore, we attempted to reveal the actual situation of the physical and the verbal aggressive behavior against the station staff in Japan and influencing factors of the aggressive behavior in the railway stations through passengers' perceptions. The results of our survey showed that the high evaluation of "Transportation" services was related to the low rate of witnessing the verbal aggressive behavior and the high evaluation of "Facilities" of the stations was related to the low rate of witnessing the physical aggressive behavior.

1 INTRODUCTION

1.1 *Aggressive behavior in public transportation*

Aggressive behavior against staffs has been a problem in public transportation. Especially for the railway station staff, the verbal and the physical aggressive behavior can be one of the issues of occupational safety and health in Japan, which has one of the most railway passengers in the world.

Actually, the Ministry of Land, Infrastructure, Transport and Tourism in Japan reported that 873 violence incidents against the railway staff occurred in Japan in 2015.

It is important to find out controllable influencing factors of the aggressive behavior to reduce the harm to the staff. However, what environmental and situational factors of the stations are generally related to such aggressive behavior is unclear because each incident seems to have its own background and reason of eliciting aggressive behavior.

In addition, although the verbal aggressive behavior may occur more frequently than the physical one, we can hardly know how frequently it occurs partly because the station staff seldom report the verbal aggressive behavior to their managers.

To cope with these difficulties, we focus on daily railway passengers who sometimes witness other passengers' aggressive behavior at the stations. In this study, we attempted to reveal the actual situation of the verbal and the physical aggressive behavior against the station staff and influencing factors of aggressive behavior in the stations through a questionnaire survey of passengers.

1.2 *Environmental and situational factors of aggressive behavior at the stations*

Although the passengers who assault the railway staff are often drunk, environmental and situational factors play an important role in eliciting aggressive behavior even under the influence of alcohol (Bushman 1997).

For example, Anderson & Bushman (2002) listed the environmental and situational factors eliciting aggressive behavior such as provocation, frustration, pain, discomfort and aggressive cues. We examined whether such factors related to aggressive behavior may exist in the stations.

For this examination, we created evaluation items of the factors of the station possibly related to aggressive behavior by reference to the available past aggressive cases, the previous studies of public safety (RSSB 2002) and service assessment of railway (e.g., Miyachi et al. 2003). These items are intended to evaluate various factors of the station including usability of station facilities, frequency of cancellations and delays of train services, convenience of transportation of the station, accessibility to the information on the services, and politeness and helpfulness of the station staff.

We examined whether passengers' evaluations of these items were related to frequencies of witnessing of aggressive behavior at the stations.

2 METHOD

2.1 *Procedure*

We conducted the survey on the WEB in order to collect the data efficiently from many users of various railway stations. Registered respondents of a web survey service who daily use the trains took part in our survey in March 2016.

We analyzed 9228 participants' responses of about 59 stations in the Kanto and the Kansai region of Japan. At least a hundred participants for each target station responded to the survey.

2.2 *Items of the questionnaire*

We asked the participants to report their experiences of witnessing other passengers' verbal and physical aggressive behavior against the station staff at the stations of their usual use and to evaluate various environmental and situational factors of the stations.

2.2.1 *Frequency of witnessing the aggressive behavior*

The participants were asked to report how often they had witnessed "the other passengers who verbally abuse the station staff" and "the other passengers who physically abuse the station staff" respectively at the stations of their usual use for the past five years on the 8-point scale shown in Table 1.

Table 1. The frequency of witnessing the aggressive behavior.

Score	Frequency
1	Never
2	Once a few years
3	Once a year
4	Every six month
5	Once a month
6	Once a week
7	Once a day
8	A few times a day

Table 2. The evaluation of environmental and situational factors of the stations.

Score	Evaluation
1	Very Poor
2	Poor
3	Slightly Poor
4	Neutral
5	Slightly Good
6	Good
7	Very Good
None	No experience

2.2.2 *Evaluation of the environmental and the situational factors of the station*

We created the 30 items of the environmental and the situational factors of the stations (Table 3). The participants were asked to evaluate the 30 items for the stations of their usual use for the past five years on the 7-point scale shown in Table 2. If they had not experienced some item of the environmental or situational factors and could not evaluate the item, they were asked to select "No experience."

3 RESULTS

We aggregated their frequencies of witnessing the aggressive behavior and evaluations of various factors for each station and analyzed the relationship between the frequencies of witnessing the aggressive behavior and the means of the evaluations of various factors of the stations.

3.1 *Frequencies of witnessing the verbal and physical aggressive behavior*

The results of frequencies of witnessing the aggressive behavior showed that the over half of the participants rated "Never" for both the verbal and the physical aggressive behavior (Fig. 1). Especially, about ninety percent of the participants reported "Never" for the physical aggressive behavior.

Thus, we treated the scores of the frequency as binary variables and convert "Never" into "non-witness" and other scores into "witness." Then we calculated the rates of "witness" of the verbal and the physical aggressive behavior for each station. We used this rates of aggressive behavior in the following analyses.

For the verbal aggressive behavior, the maximum rate was 75.4% and the minimum rate was 19.6%, and for the physical aggressive behavior, the

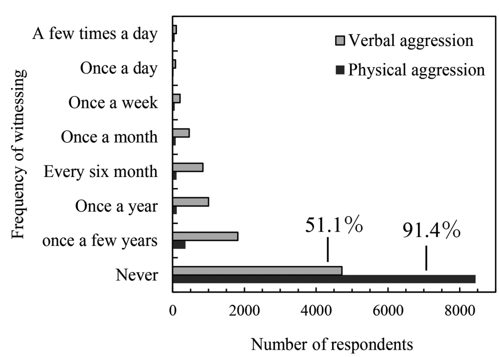


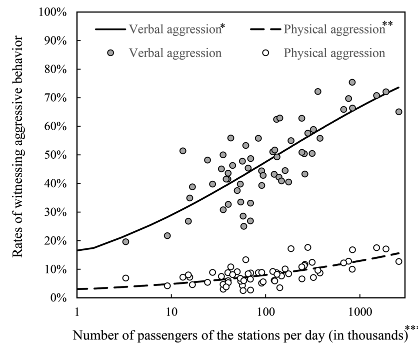
Figure 1. Number of respondents against frequencies of witnessing the verbal and the physical aggressive behavior (N = 9228).

maximum rate was 17.6% and the minimum rate was 2.5% at the targeted stations (Fig. 2).

3.2 *Relationship between rates of witnessing aggressive behavior and the number of passengers of the stations*

Naturally, the participants who use the stations where there are many passengers witnessed the aggressive behavior more frequently. Hence, as the first step, we checked the relationship between the rates of witnessing the verbal and the physical aggressive behavior and the number of passengers of the stations.

The results showed that the rates of witnessing the verbal and the physical aggressive behavior increased according to the increasing number of passengers of the stations as predicted, but still some variances existed which could not be explained by the number of passengers only.



*$y = 1 / (1 + \exp(4.09–0.80\log_{10}x))$; $R^2_{McFadden} = 0.64$
**$y = 1 / (1 + \exp(5.11–0.53\log_{10}x))$; $R^2_{McFadden} = 0.44$
***The horizontal axis is graduated on a logarithmic scale.

Figure 2. Rates of witnessing the verbal and the physical aggressive behavior as a function of the number of passengers of the stations (N = 59).

Table 3. Summary of the evaluation items of the environmental and situational factors of the stations and the component loadings (Okada et al. 2017).

	Component loadings*			
Item	C1	C2	C3	C4
Degree of crowding in the station in the night rush hour	0.84	0.20	–0.32	0.18
Usability of the automatic ticket gates	0.81	0.13	0.13	0.36
Support of the station staff at the ticket gates	0.81	0.34	0.27	0.21
Politeness of the station staff	0.80	0.37	0.26	0.15
Usability of the automatic ticket vender	0.79	0.03	0.15	0.43
Mobility inside the station	0.79	0.16	–0.10	0.47
Appropriateness of appearances of the station staff	0.76	0.32	0.32	0.22
Degree of crowding in the train in the night rush hour	0.76	0.40	–0.20	0.16
Support of the staff at the ticket counter	0.75	0.28	0.35	0.27
Familiarity of the station staff	0.74	0.38	0.34	0.17
Explicitness of signposts in the station	0.71	0.43	–0.03	0.44
Understandability of announcements in the station	0.65	0.62	–0.06	0.32
Appropriateness of support of the station staff for finding situations inside and around the station	0.64	0.61	0.15	0.27
Accessibility to the smoking area in the station	0.63	0.28	–0.11	0.01
Appropriateness of support of the station staff at the platforms	0.61	0.61	0.15	0.27
Explicitness of the signposts of arrival trains and boarding positions at the platforms	0.60	0.50	0.19	0.50
Frequency of train delays and cancellations	0.24	0.86	0.06	0.07
Appropriateness of providing the information about train delays and cancellations by the station staff	0.46	0.78	–0.03	0.24
Understandability of announcements in the train	0.57	0.71	0.11	0.22
Appropriateness of brightness and humidity in the train	0.38	0.64	0.30	0.45
Appropriateness of train fare	–0.12	0.62	0.56	0.08
Appropriateness of support of the station staff to passengers' requests or comments	0.54	0.62	0.26	0.23
Appropriateness of vibration and noise in the train	0.37	0.60	0.44	0.24
Frequency of train service to destinations	–0.12	0.11	0.94	0.04
Flexibility of route choice to destinations	–0.01	0.11	0.94	0.04
Appropriateness of riding time to destinations	0.12	–0.03	0.93	0.12
Smoothness of train connection at transfer stations	0.36	0.17	0.81	0.06
Usability of bathrooms in the station	0.22	0.19	0.07	0.83
Appropriateness of brightness and humidity inside the station	0.35	0.21	0.21	0.81
Security inside the station	0.54	0.30	0.01	0.70

*C1 = "Station", C2 = "Transportation", C3 = "Route", C4 = "Facilities"

In addition, the verbal aggressive behavior was witnessed more frequently than the physical one regardless of the number of passengers of the stations.

3.3 *Relationship between the environmental and the situational factors of the stations and the frequencies of the aggressive behavior*

We examined the relationship between the rates of witnessing the aggressive behavior and the evaluation of environmental and situation factors of the stations in consideration of the number of passengers of the stations.

We applied a principal components analysis with varimax rotation to the mean values of the evaluation of 30 items of each station. We extracted four principal components based on the eigenvalues greater than 1 and these four components accounted for 83.8% of the total variance.

Component 1 was highly loaded by the items of the general evaluation of "Station" such as degree of crowding in the station or train, usability of the station equipment and politeness and helpfulness of the station staff. Component 2 was highly loaded by the items of the evaluation of "Transportation" such as frequency of cancellations and delays of train services and accessibility of information on the services in the station or train. Component 3 was highly loaded by the items of evaluation of "Route" such as flexibility of route choice and frequency of train service. Component 4 was highly loaded by the items of the evaluation of "Facilities" such as usability of bathrooms in the stations and appropriateness of brightness and humidity in the stations (Table 3).

Then, we conducted multiple logistic regression analysis to reveal how the four principle components and the number of passengers were related to the rates of witnessing the verbal and the physical aggressive behavior.

The results showed that the number of passengers and the "Transportation" component were significantly related to the rate of witnessing of the verbal aggressive behavior, while the number of passengers and the "Facilities" component were significantly related to the physical aggressive behavior (Table 4).

In other words, high evaluation of "Transportation" were related to the low rate of witnessing verbal aggressive behavior and high evaluation of "Facilities" was related to the low rate of witnessing physical aggressive behavior regardless of the number of passengers of the stations.

Table 4. Summary of multiple logistic regression analysis estimating the rates of witnessing the verbal and the physical aggressive behaviour.

	Verbal aggression****		
Predictor variable	β	SE	Odds ratio
Number of passengers*	0.64***	0.07	1.90
C1 "Staion"	–0.01	0.03	0.99
C2 "Transportation"	–0.26***	0.03	0.77
C3 "Route"	0.00	0.03	1.00
C4 "Facilities"	–0.02	0.02	0.98
	Physical aggression*****		
Predictor variable	β	SE	Odds ratio
Number of passengers*	–0.48***	0.11	1.63
C1 "Staion"	–0.04	0.05	0.96
C2 "Transportation"	–0.03	0.04	0.97
C3 "Route"	–0.05	0.05	0.95
C4 "Facilities"	–0.10**	0.04	0.90

*The number of passengers was transformed using the logarithm function.
**p <0.01, ***p <0.001.
****$R^2_{McFadden} = 0.83$.
*****$R^2_{McFadden} = 0.51$.

4 DISCUSSION

The results of our study showed that both the verbal and the physical aggressive behavior increase according to the increasing number of passengers of the stations and the verbal aggressive behavior occurs more frequently than the physical one.

More importantly, the results showed that the verbal aggressive behavior was related to "Transportation" issues such as frequency of cancellations or delays of train services and accessibility of information, while the physical aggressive behavior was related to "Facilities" condition such as usability of bathrooms in the stations and appropriateness of brightness and humidity in the stations.

This result suggests that frustration due to poor transportation service may lead to the verbal aggressive behavior, but seldom leads directly to the physical aggressive behavior. Moreover, as the well-known "Broken Windows theory" suggests, creating clean and ordered environments may lead to preventing the physical aggressive behavior.

However, we could not judge the validity of these relationships regarding causality exactly since the results of this study were relied on correlations between witnessing the aggressive behavior and the evaluations of the various factors of the stations by the eyewitness. Hence, there is a possibility that the participants who witnessed the aggressive behavior evaluated the factors of the station worse.

In future, further research should examine the relationship more directly through controlling individual level effects of witnessing and evaluations by using multilevel analysis or using more objective variables such as actual number of cancellation and delays of trains.

5 CONCLUSION

Although more research is necessary in future, this study suggests that improving "Transportation" and "Facilities" of railway stations may prevent the aggressive behavior against the staff, which is one of the issues of occupational safety and health.

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"Healthy workplaces for all ages"—age related changes and occupational health and safety

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ABSTRACT: In the last decades, humanity experiences an increasing demographic change. Ageing of the population is directly connected with ageing of the workforce. The proportion of older people is growing, while fewer young people enter the labour market. This paper seeks to identify the possible relationships between age, work and Occupational Health and Safety (OHS) in the workforce of Cyprus. Some of the main elements of the ageing management have been used to enhance the Plan—Do—Check—Act (P-D-C-A) approach of an Occupational Health and Safety Management System (OHSMS). A nationwide study, was conducted by the Cyprus Safety and Health Association (CySHA) with the collaboration of the Department of Labour Inspection (DLI) of the Republic of Cyprus. A quantitative tool in the form of a structured questionnaire was used. The questionnaire was given to employers in accordance with the "Healthy Workplaces for all Ages" campaign of the European Agency of Health and Safety at Work. The aim of the campaign "Healthy Workplaces for all Ages" is to keep welcoming young workers but at the same time, protect older workers and suggest adaptation measures if necessary. Strategies to minimise age related issues and increase awareness should be designed and adopted at the early stages of working life and continue until retirement. This is a win—win situation where, by reducing risk factors of employees, the rate of occupational accidents and occupational diseases decreases thus, lowering costs for employers. The study aims to understand among others: whether employers consider worker's age when they conduct a Risk Assessment (RA); the level of employers awareness of the changes that older workers are facing and whether they are willing to take action; and whether companies have a recovery plan when an older worker is back to work after a long sick leave due to an occupational disease, etc.

Keywords: ageing; risk assessment; occupational accidents; occupational diseases; adaptation measures

1 INTRODUCTION

The last decades have shown an increasing demographic change. Ageing of the population is directly related with ageing of the workforce with 55% of the world's governments consider this as a major concern (UN, 2013). The proportion of older people is growing, while fewer young people are entering the labour force. As a result of that, there have been changes to the employment rate of those aged 55–64 years. Many EU countries have increased the official retirement age to 65+ for both men and women, while others are in the process of increasing the retirement age even further (EU-OSHA, 2016). Special attention must be taken not only to older people (above 50) but additionally into this new potential group of workers above 65 years old in order to prevent accidents and continue working in a safe environment.

Occupational health and safety should be reconsidered taking into consideration this new evaluation of risk. For these ageing groups, the risk of occupational accidents and diseases is now even higher due to their extended exposure time to specific hazards. Older workers are at a higher risk in relation to self-reported health problems and long-term sickness absence (Niedhammer et al., 2008) while younger people claim to be more exposed to all types of risk at work. However, older workers are seen as having lower accident rates than younger workers (Benjamin and Wilson, 2005), probably due to the less dangerous work environment that they choose to work in at this age (Laflamme et al., 1996). Additionally, older workers are more at risk of fatal accidents (Grandjean et al., 2006) and take longer to recover from non-fatal serious injuries (Laflame and Menckel, 1995).

According to The Safety and Health at Work Laws of 1996 to (N.2) of 2015 (178(I) of 2015), employers have a legal duty to ensure the safety and health of their employees. This includes the identification of hazards arising from work related activities and the evaluation of risks. There is a complex interaction between ageing, work and

**Board Member of Cyprus Safety and Health Association (CySHA)*

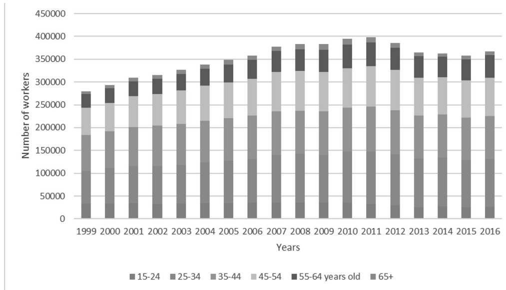
OHSMS. Ageing results in mental and physical changes which might affect work and OHSMS but there is a large variation between individuals. These changes affect the evaluation of risk and employers should be aware of them. A first step could be to recognize these new hazards in their safety policy and then in the whole OHSMS. However, in Cyprus there are no specific government policies to encourage SMEs to adopt safety policies (Boustras et al., 2015). The Department of Labour Inspection (DLI) with its inspectors try to set even more higher standards in order to meet EU guidelines. Population ageing and the related challenges for workplaces have not been the main priority for policy development in Cyprus according to the literature and empirical research (EU-OSHA, 2016). Cyprus was one of the countries hit by economic crisis, and efforts have been focused on reducing youth unemployment rather than dealing with population ageing challenges.

This paper illustrates the general framework of the changing workforce in Cyprus, presenting potential measures that should be taken from employers to promote sustainability across the working life. This life-course approach is the key to promoting a longer working life and healthy retirement. This paper aims to address:

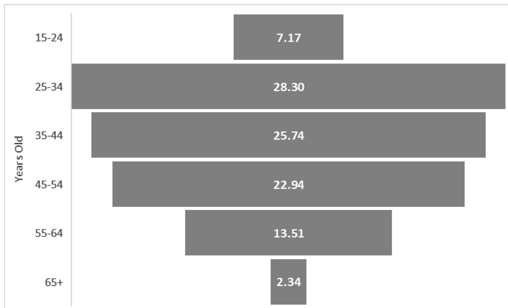
- ageing workforce challenges through an OHSMS, answering questions such as whether risk assessors take into account ageing issues when they develop a RA or if companies have a recovery plan when an older worker is back to work after a long sick leave due to an occupational disease.
- basic adaptation measures to minimize risk and prevent occupational accidents
- future work recommendations that might need to be carried out based on the results of the questionnaire and a systematic literature review.

2 LITERATURE REVIEW

Ageing is a complex and continuous process that begins with birth and ends with death. It is a multidimensional process of biological, psychological and social changes (EU-OSHA, 2016). Population ageing is a major trend that has an impact on societies and economies, influencing all spheres of life. Alongside the population, the labour force is ageing. It has become one of the most important problems globally, especially in Europe (Mockus, Zukaite, 2012 from Rūta Čiutienė and Rasa Railaitė 2014). The Cyprus population is considerably younger than the average population of Europe. In 2015 the median age in the EU-28 was around 42,2 years, while in Cyprus it was 36,8 years. As it can be seen from Graph 1 and Graph 2, the employment rate among people aged 55 or over



Graph 1. Cyprus workforce be age groups and years. Source: Own calculation based on Statistical Service of Cyprus (2016).



Graph 2. Ageing workforce (%) in Cyprus (2016). Source: Own calculation based on Statistical Service of Cyprus (2016).

has been slightly increasing since 1999. In particular, in 1999 it was 12,61%, in 2007 it was 14,91% and in 2016 it was 15,84%. However, this age group is projected to increase slowly until 2020 and grow rapidly throughout the 2040s and 2050s (EU-OSHA, 2016). For that reason, now is the time to prepare, set policies and develop OHSMS that recognise the ageing factor, before these changes affect the workforce, society and the economy.

2.1 *Age-related physiological and psychological changes*

Changes occur with ageing. Attributes such as work experience, expertise, wisdom, strategic thinking accumulate with age. Work motivation does not necessarily decline with age—yet age may negatively affect motivation for certain tasks, such as training (CEDEFOP, 2012). According to McGregor and Gray (2002) older workers are reliable, loyal, committed to the job and willing to stay longer in the job. Of course, this depends on the job characteristics as computer experience, innovation, creativity, enthusiasm are the least typical for older workers (Čiutienė and Railaitė, 2014). Older workers are also, less likely to adapt to new tasks (Bal et al., 2011).

On the other hand, some functional capacities (mainly physical), decline as a result of the natural ageing process. (OSHA, 2016). Characteristics that may occur due to ageing are: decreased joint mobility (& the ability of people to egress buildings), loss of strength, reduced physical functional capacity, slowed decision making, attention deficits, memory deficits, visual deficits, reduced colour discrimination, less tolerance for heat/cold, hearing loss, highest risk for Musculoskeletal Disorder (MSD), slower rehabilitation from injury or disease and higher work stress. It is important to keep in mind that biological ageing is only loosely associated with person age in years. There is no 'typical' older person; some 80 year–olds have physical and mental capacities similar to many 20 year-olds (WHO, 2016). Thus, there can be considerable differences between individuals of the same age because of differences in lifestyle, nutricion, fitness, genetic predispositions, educational level, etc (European Commission, 2016).

These changes might affect in different ways different occupations. For example, changes in balance and strength might affect fire fighters and rescue personnel who work in extreme conditions, wearing heavy equipment and lifting and carrying people. These changes in balance might also affect everyone working at height. In addition, a decreased ability to judge distances and the speed of moving objects has an implication for night-driving but does not affect office workers (European Commission, 2016).

Difficult working conditions and unhealthy work environments might reduce productivity of older workers, increase their absenteeism rate and the probability of losing their jobs, encouraging them to leave the labour market early (Blanchet, 2005). Indicators such as working at speed and to tight deadlines, using mental and physical energy might affect work intensity index. According to Eurofound (2016), Cyprus has the highest work intensity index in the EU which affect the effectiveness of performing tasks. However, older workers report lower work intensity than the other age groups.

Good occupational health and safety management seeks among others to identify hazards, reduction of risk and prevent of occupational accidents and occupational diseases. This paper aims to include ageing factor in this procedure in order to have an even more effective OHSMS in the context of an ageing workforce.

2.2 *Age management as part of the P-D-C-A approach and the OHSMS*

Age management is the approach that this paper aims to include in an OHSMS. According to (EU-OSHA, 2016) age management is holistic, intergenerational, life-course oriented and refers to human resources with an explicit focus on the requirements of an ageing workforce. The main dimensions of age management are a) recruitment processes which focus on skills and experience avoiding age discrimination, b) knowledge transfer, training and life-long learning, c) career development, d) flexible working time practices, e) workplace health promotion, f) occupational safety and health management, g) job rotation, h) employment exit and the transition to retirement. These elements could be included in an OHSMS and be part of the P-D-C-A approach. According to Ilmarinen (2012), age management means that age related factors should be taken into consideration in daily management through an OHSMS. This includes work arrangements and individual work tasks, so that everybody, regardless age, feels empowered in reaching their own and corporate goals. This might be the key to productivity and work satisfaction.

3 METHODOLOGY

A nationwide study, was conducted by the Cyprus Safety and Health Association (CySHA) with the collaboration of the Department of Labour Inspection (DLI) of the Republic of Cyprus. A quantitative tool in the form of a structured questionnaire was used. The questionnaire was given to employers in accordance with the "Healthy Workplaces for all Ages" campaign of the European Agency of Health and Safety at Work. According to Babbie (2010) quantitative methods emphasise objective measurements and numerical analysis of data collected through questionnaires or surveys. The questionnaire was prepared based on theoretical findings. It has been designed in a way that will allow an analysis of all the steps of an OHSMS Figure 1. The survey was carried out in Cyprus during 2016. Examination of the empirical results was based on comparative analysis.

Firstly, the authors have identified the ageing process issues among older workers. Thus, ageing and physical changes were identified. The second step was the listing of the major elements of an OHSMS so that ageing and work organization factors could be identified.

The paper is based on the results of a wider study on ageing workforce challenges and management of SMEs in Cyprus, on scientific literature analysis and on statistical data. The questionnaire survey that was conducted can be considered as a pilot study under this wider project. In order to guarantee a fair result, as objective as possible, the survey tool (questionnaire) was conducted among 133 SMEs from several economic sectors. Initially 200 enterprises had been contacted, while 133 agreed to cooperate (with an effective response rate of 66,5%). The sample is representative of the

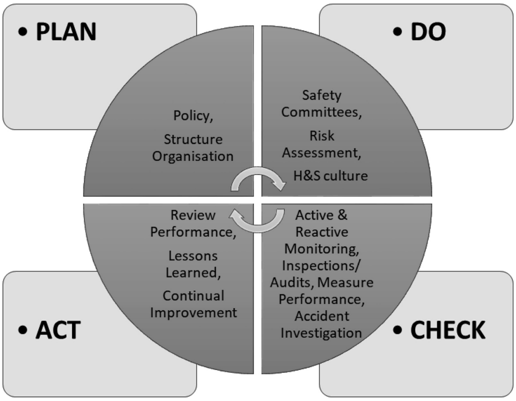


Figure 1. P-D-C-A approach with its main elements. Source: Own construction based on Hughes (2016).

main economic sectors of Cyprus (Services 41%, Others 27%, Construction 13%, Manufacturing 12%). Due to lack of space not all descriptive results are reported in this paper.

Owners/managers were the only respondents of this survey and they have been chosen due to the fact that they are directly involved in health and safety issues from the management point of view in an enterprise. Questions were asked to owners/managers about the existence of an OHS risk assessment in the enterprise and if ageing is used as an extra risk factor in its development. There were also questions on the provision of training for older workers on health and safety issues, the provision of return to work plans and the existence of adaption measures etc.

4 RESULTS AND DISCUSSION

It should be noted that, in total, the questionnaire included 20 questions. As a result, only absolutely relevant descriptive statistics are presented in this paper and a correlation of the main variables. As mentioned before, questions were conducted based on the P-D-C-A approach, thus results below are presented in the same order:

4.1 *PLAN stage*

As a first step, a descriptive analysis of the basic questionnaire's items was conducted (type of industry, number of employees etc). Respondents were from different kinds of SMEs of Cyprus' labour market. This should be considered as structure of 'organisation step' in the P-D-C-A approach.

One of the first steps of an OHSMS is the development of a Health and Safety (H&S) Policy. Policies have been designed to meet legal requirements, prevent health and safety problems, and enable organisations to respond quickly where difficulties arise or new risks are introduced (HSE, 2013). In this H&S policy, ageing issues should be considered and the commitment of the organization to be in line with legislation should specifically apply to all ageing groups.

4.2 *DO stage*

RA is the cornerstone of effective health and safety management and leads to a sustainable working environment. The most important thing to remember when it comes to RA is that each workplace and each worker may face unique OHS risks. Legislation does not prescribe exactly how to conduct a RA although for some specific high-risk sectors or activities coverage of certain elements/risks can be required.

When carrying out RA, special attention should be paid to groups of workers who may be especially vulnerable. These groups are for example young workers, older workers, people with disabilities, pregnant women. Based on that, for older workers, additional risks are related to potential changes in functional capacities, while for young workers, additional risks include lack of experience. Other hazards that need to be considered specifically for older workers are ergonomic hazards (repetitive movements, manual handling, uncomfortable or static postures), shift work, noise, vibration, hot or cold environment, working at height etc.

Table 1 shows that a very high percentage of the companies surveyed (80%) have a RA which is comparable to the EU-OSHA results for European countries (77,23%). However, only 46% declared that they have considered the ageing factor on their RA. That gives an answer to one of this paper's objectives. Employers do not recognise ageing changes as an extra element in their RA.

Another question, was about participation in training. Older workers are participating in training sessions (75%) according to this questionnaire. This means that there is no discrimination, at least from the employer for older workers or/and that

Table 1. Existence of RA and consideration of the ageing factor in the RA.

Variable	Existence of RA		Considering age in the RA	
Response	Frequency	Valid percent	Frequency	Valid percent
Yes	107	80	61	46
No	26	20	72	54
Total	133	100	133	100

older workers are willing to learn. However, 59% of the Cypriots older workers consider that age discrimination exists in their workplace (EU-OSHA, 2016). The fact that ageing issues might not be addressed in a company, may mean that training methods might not suit older workers. Training methods should be adapted to a company's and an employees's needs. It is important to train workers upon recruitment, when they are transferred or change jobs, when new technology and equipment is introduced and when new hazards have been identified (European Commission, 2016).

There was a question about the existence of mentoring programme from older workers to younger workers. The results were positive, since 64% answer that mentoring programmes do exist in their companies. These types of programmes are inexpensive and could benefit everyone. Younger employees could gain from older worker's experience and knowledge while this might increase job satisfaction and self-confidence of older workers.

4.3 *CHECK stage*

According to the majority of respondents, they do not keep records for health surveillance monitoring (55%). This issue needs to be addressed, particularly for part-time workers and small businesses (EU-OSHA, 2016). Health surveillance aims to detect undesired health effects. Workers who are regularly exposed to high risk substances or activities at their work, should be monitored even more often. Health surveillance and early intervention should be the aim for every employer in order to keep their workforce healthy.

Accident investigation is an important step of the 'check stage'. Accidents, incident and near misses need to be investigated in order to avoid the same mistakes in the future. It is important to check 'near-misses' that had the potential to result in injury, illness or damage but fortunately did not. For every reported major injury, there are 300 near misses (European Commission, 2016). The investigation of accidents regarding ageing is a future step for the authors.

4.4 *Act stage*

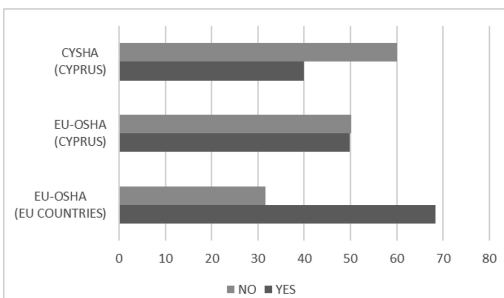
Many of the older workers might face health problems during their work life. The longer they are off work, the more barriers they experience in going back and the lower the likelihood of successful and lasting return to work (EU-OSHA, 2016). There must be a plan with the cooperation of the employer, the worker and maybe the healthcare services. According to this survey, 40% of the companies in Cyprus have a return-to-work/ recovery plan. EU-OSHA survey, found that in average European countries have procedures to accept employees after a long-term sickness absence (68%), while in Cyprus 49,9% reported that they have (Table 2). It is important to consider practical measures to support returning older workers. These measures could be the adaptation of the workstation or a more flexible work schedule. For example, they might need physiotherapy sessions or to attend medical appointments so, they should have flexible working hours.

The majority of respondents (61%) have mentioned that adaptation measures to help older workers do not exist in their OHSMS, which shows that they might not be aware of the issues related to ageing. On the other hand, they are willing to allow job rotation for older workers of the company if there is a need (58%). Moreover, 83% of these employers are also willing to change someone's position due to health issues. The last two answers show that there is a will from employers to keep workers and they use adaptation measures without recognising that these might be adaptation measures to help older workers. Other examples of adapting the workplace include adapting existing equipment or providing new equipment to eliminate manual handling, repetitive movements and awkward postures. In addition, rotating tasks, adding more mini breaks, adjusting lighting and changing shift patterns to meet the needs of older workers are other examples of adaptation measures.

According to Northcott (2011) older workers might choose to leave their work early due to the changes in the pension systems. However, most of the self-employed and managers trend to continue after retirement age (Special Eurobarometer 378, 2012). In Cyprus, it seems that 16,5% choose to quit working due to health issues while in EU this proportion is 20,9% (EU-OSHA, 2016). However, there is a tend to stay at work due to the fact that most of the SMEs in Cyprus are family business.

Table 3 presents some interesting correlations not directly related to the main objectives and hypoth-

Table 2. Existence of recovery plan.



Source: Own calculation based on EU-OSHA (2016).

Table 3. Correlation between main variables.

Variable	1	2	3	4	5	6	7	8	9	10
1. Type of organisation/ company	1									
2. Age of the organisation/ company	0.176	1								
3. Considering age in reviewing performance	0.069	0.053	1							
4. Existence of RA	0.030	0.008	–0.011	1						
5. Considering age in the RA	–0.129	–0.100	0.288	0.286	1					
6. Considering physical conditions in the RA	–0.146	–0.119	0.282	0.332	0.713	1.000				
7. Measures taken to help older workers	0.114	–0.055	0.266	0.026	0.407	0.363	1			
8. Existence of job rotation plan due to ageing	0.138	–0.062	0.231	0.094	0.327	0.156	0.246	1		
9. Job rotation due to health issues	0.047	0.019	0.187	0.355	0.247	0.294	0.191	0.358	1	
10. Existence of training for older people	–0.108	0.039	–0.002	0.167	0.144	0.188	0.175	0.074	0.166	1

Figure 2. Ageing management as part of the P-D-C-A approach.

esis of this paper. There is a significant and relatively high correlation (r = 0.713) between the variable cosidering of physical conditions in the RA and the considering of the factor age in the RA. This relationship, taking into account the above results of job rotation, probably indicates that employers are willing to make changes and adaptations in their RA, however they do not recognize that these changes might arise from the factor age.

Good OHSMS is important for large companies, but it is vital for SMEs. The explanation of this, relies on the fact that it is more difficult for SMEs to recover from a costly accident/ incident which may lead to the closure of the business (European Commission, 2016). OSH aspects of age management can be accommodated within the workplace RA and management process (EU-OSHA, 2016). For the aims of this study, recommendations have been made for each of the basic OHSMS steps in order to illustrate the main elements of age management through the application of an OHSMS. Figure 2 illustrates the additional patterns on the P-D-C-A approach, as a summary of all the elements that have been tested in this survey.

5 CONCLUSION

The concept of active ageing highlights that 'if people are to work for a longer period of time, then they will need to be in good physical and mental health, with access to more flexible working arrangements, healthy workplaces, lifelong learning and retirement schemes' (European Union, 2012, p. 37). This paper presented an analysis of ageing management issues and practices and their addition to an OHSMS through the P-D-C-A approach. The authors findings were based on literature review and in survey results.

The effectiveness of potential interventions on older workers should be checked regularly. Early intervention is the key for a healthy and safe workplace. An OHSMS is based on continual improvement and this should be the aim for each and every employer: to address strategies to improve health and safety standards and develop a strong RA considering all the ageing issues. Furthermore, more knowledge and research is needed in relation to extending the working life beyond 65 years of age. Companies that don't appreciate the need to address the challenges of the ageing workforce, may be putting their productivity and competitiveness at risk. Satisfied and healthy employees give productivity and high employment participation which results to high quality of work. Attention must be paid from the scientific community, policy-makers and business leaders to all age groups and their specific needs including ageing issues. These issues should be addressed in every OHSMS, in order to keep employees healthy through their working life and use as an advantage older workers' knowledge.

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