# Assessment of the Contribution of Safety Knowledge to Sustainable Safety Management Systems in Estonian SMEs

MARINA  JÄRVIS

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TALLINN UNIVERSITY OF TECHNOLOGY
Tallinn School of Economics and Business Administration
Department of Business Administration

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**Supervisors:** Professor Piia Tint, PhD
Department of Business Administration,
Tallinn University of Technology, Estonia

Professor Charles Alexander Woolfson, PhD
Institute for Research on Migration, Ethnicity and Society
Linköping University, Sweden

**Opponents:** Professor Jānis Ieviņš, PhD
Riga Technical University, Latvia

Professor emeritus Kaj Harald Frick, PhD
Luleå Technical University, Sweden

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Declaration:
*Hereby I declare that this doctoral thesis, my original investigation and achievement, submitted for the doctoral degree at Tallinn University of Technology has not been submitted for any academic degree.*

Marina Järvis

# Ohutusteadmiste hindamine ohutusjuhtimises jätkusuutlikkuse tagamiseks Eesti väikestes ja keskmistes ettevõtetes

MARINA  JÄRVIS

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# CONTENTS

# LIST OF PUBLICATIONS

The thesis is a collection of seven original publications. The publications are referred to in the text below by their respective Roman numerals:

I. Reinhold, K.; **Järvis, M.**; Tint, P. (2009) Risk Observatory - A Tool for Improving Safety and Health at the Workplace. *International Journal of Occupational Safety and Ergonomics*, Volume 15, No 1: 101-112. (ETIS 1.1)

II. **Järvis, M**.; Tint, P. (2009) The formation of a good safety culture at the enterprise. *Journal of Business Economics and Management*, Volume 10, No 2: 169-180. ( ETIS 1.1)

III. Tint, P.; **Järvis, M.**; Reinhold, K.; Paas, Õ. (2009) Risk Assessment and Measurement of Hazards in Estonian Enterprises. *Environmental Engineering and Management Journal*. Volume 8, No 5: 1165-1170. (ETIS 1.1)

IV. **Järvis, M.**; Tint, P. (2009). Innovations at workplace: an evidence based model for safety management. *Journal Business: Theory and Practice*. Volume 10, No 2: 150-158. (ETIS 1.2)

V. **Järvis, M.**; Virovere, A.; Tint, P. (2013). Formal Safety Versus Real Safety: Quantitative and Qualitative Approaches to Safety Culture – Evidence from Estonia. *Proceedings of the Latvian Academy of Sciences* (forthcoming, ETIS 1.2).

VI. **Järvis, M.**; Virovere, A; Tint, P. (2013). Knowledge Management: a neglected dimension in discourse on safety management and safety culture – evidence from Estonia. *Scientific Journal of Riga Technical University* (forthcoming, ETIS 1.2)

VII. **Järvis, M.**; Virovere, A; Tint, P. (2013). Managers' perceptions of organizational safety: implication for the development of safety culture. *Scientific Journal of Riga Technical University* (forthcoming, ETIS 1.2).

# The author's contribution to the publications

**Paper I.** In *Article I* the author of the thesis was responsible for the general framework and analyzed the changes in the working environment in 2002-2006 and the effectiveness of the present occupational health and safety system in Estonia.

**Paper II.** The author of this thesis is the primary author of *Article II.* The author participated in the auditing of safety management systems in the investigated enterprises and analyzed the working environment as well as employees' and employers' opinions towards health and safety. In addition, the author conducted a survey of occupational health and safety professionals in Estonia.

**Paper III.** The author participated in data collection from the investigated companies as well as in writing the article. The author analyzed and interpreted the survey results.

**Paper IV.** The author wrote the paper, conducted seven case studies in the enterprises and developed a conceptually innovative model for the improvement of safety culture consisting of knowledge management dimensions. In addition, the author conducted comparative surveys of occupational health and safety professionals in 2002 and 2009 and analyzed the survey results.

**Paper V.** The author wrote the paper, conducted qualitative research (case studies, safety interviews, observation, and document analysis) in the eight investigated enterprises. In addition, the author participated in writing the theoretical part of *Article V*, in the national media analysis and in the data analysis of a national Work Environment questionnaire survey and prepared the figures.

**Paper VI.** The author wrote the paper, participated in the development of the reciprocal safety culture model further proposed by the author as well as in the data analysis of a national Work Environment questionnaire survey in order to empirically test the proposed model.

**Paper VII.** The author conducted the case studies in eight SMEs (observation, safety interviews, and document analysis) and analyzed the results. In addition, the author participated in the analysis of the national Work Environment questionnaire survey as well as in the organizational context of safety culture.

There was close co-operation between the authors; the author of this thesis had a leading developmental role. All the articles benefited substantially from this co-operation, cross-reading, discussions and suggested improvements.

# INTRODUCTION

This research focuses on safety management challenges within the manufacturing small and medium-sized enterprises (SMEs) in Estonia. A status picture of the safety culture and safety knowledge, interrelationships between safety management systems and organizational factors are presented.

At present, each organization needs to be adaptable to the changing environment in order to survive in the global competitive environment. It means that each manufacturing organization requires or seeks for better products and quality, more efficient production, shorter delivery time, and a safe working environment for its employees. Managing occupational risks in an integrated way within the organization's operations has become increasingly essential in recent years, since it can positively affect not only accident rates and safety performance of an organization, but also have a positive influence on competitiveness performance and the organization's productivity, the economic-financial performance of an organization and on the control of workers' safe behavior (Fernández-Muñiz et al., 2009; Stolk, et al., 2012; O'Toole, 2002). However, much confusion remains about the definition and characteristics of the concept of the occupational health and safety management system (OHSMS) (Frick et al., 2000; Stolk et al., 2012; Fernández-Muñiz et al., 2009). The scientific literature on OHSMSs often distinguishes mandatory/regulated OHSM from voluntary systems, which clearly distinguish the concept of OHSMSs from the concept of systematic OHSM (Frick et al., 2000; Robson et al., 2007). Policy and regulatory requirements have an acknowledged impact on safety performance, but "safety excellence is a product not only of the right programs… but also of the right culture" (Simon and Cistaro, 2009; p.30).

In this thesis a safety management system (SMS) is a ***key concept***, which plays a vital role in the success of a manufacturing organization. A SMS can be defined "as an integrated mechanism in organizations designed to control the risks that can affect employees' health and safety, and at the same time to ensure the firm can easily comply with the relevant legislation" (Fernández-Muñiz et al., 2009, p 981). It also implies a systematic approach to managing safety, including the necessary organizational structure, technical, social, accountabilities, policies and procedures, managerial functions and organizational capabilities. A SMS is the planned and systematic top management-driven activity, which is a function that enhances organizational performance by predicting operational, procedural or environmental risks and threats before they occur based on the analysis of past operational experiences. Many studies emphasize that a good SMS should be fully integrated in the firm general management, be an organic and cohesive system, consisting of policies, strategies and procedures that provide internal consistency and harmonization (Fernández-Muñiz et al., 2009; Frick and Kempa, 2011; Frick, 2011). According to Fernández-Muñiz et al. (2009) and Stolk et al. (2012), there is lack of

empirical research identifying the specific dimensions of adequate SMS and on the application of OHSMSs in SMEs as well as micro-businesses. At the same time, there are higher accident rates in SMEs than in the larger enterprises (Micheli and Cagno, 2010; Fabiano et al., 2004). The main reason that can explain the generally low commitment of SMEs towards health and safety management can be the lack of capacity and relevant safety knowledge of SMEs to assess and control risk in an effective way because of the limited access to human, economic, and technological resources (Champoux and Brun, 2003; Micheli and Cagno, 2010). According to Yun (2012), many companies, especially SMEs, have viewed OH&S as a necessary element of compliance rather than as a contributory factor to the economic viability of their organization. In addition, there is lack of empirical research identifying the specific dimension for an effective OHSMS (Santos-Reyes and Beard, 2002; Fernández-Muñiz et al., 2009) and existing SMS and models are not effective for SMEs and do not assess complex socio-technical systems (Reiman et al., 2005; Makin and Winder, 2008; Champoux and Brun, 2003; Saksvik and Quinlan, 2003).

Reiman et al. (2005) stated that an organization has a high potential for safety and positive and strong SMS when the following criteria are met in the organizational activity: safety is a clearly recognized value and understood as a complex and systemic phenomenon; safety is integrated into all daily activities; organization is mindful in its practices and activities are organized in a manageable way; occupational hazards and core task requirements are clearly understood and responsibility is taken for the safe functioning of the whole system; safety is learning-driven. When safety becomes a value and is demonstrated through employers' and employees' individual attitudes, perception, and behavior, the process develops into a safety culture. Safety culture has been defined by Cooper (2000) as : "… the sub-facet of organizational culture that is thought to affect members' attitudes and behavior in relation to an organization's on-going health and safety performance …" Similarly, other researchers defined safety culture as the product of the individual and group shared values, attitudes, beliefs, risk-perceptions (Lee and Harrison, 2000), competencies, norms, principles, and patterns of behavior that determine the commitment of employees to health and safety, as well as the style and proficiency of an organization's health and safety programmes (HSE, 2005). Schein (1992) claims that the way in which senior managers reward, instruct, allocate resources and their attention as well as behavior under the pressure, will be particularly salient in shaping organizational (safety) culture. Other researchers (Cooper, 2001; Clarke, 1999; Brown and Trevino, 2012) suggested that perceptions of senior managers' attitudes and behaviors in relation to the health and safety, well-being of workforce will form the basis for the safety behavior of employees, and therefore, the safety performance of the organization.

In common with most conceptualizations, these definitions emphasize the critical and essential link between safety culture and the health and safety management system through shared values and beliefs that guide behavior patterns and health and safety activities in the organization. A strong safety culture is generally considered as a vital condition to well-functioning SMSs (Bently and Tappin, 2010; Fernández-Muñiz et al., 2009; Edwards et al. 2013).

Safety through technical design and management of physical or tangible resources/assets, such as safer technology, regular audits and proper risk assessment; use of less hazardous chemicals and the elaboration of safe procedures, safety policies and guidelines, is still entirely relevant to ensuring safe and healthy work systems, but in itself it is now regarded as insufficient. As a part of a SMS, it is important to focus on managerial and organizational factors as well as better understand the psychological and social preconditions for employees' unsafe behavior and accident causation. In the context of the management of OH&S, special attention should be given to intangible resources/ assets of an organization, obtained through human OH&S experience and practice in the workplace. Safety knowledge can be conceptualized as an employee understanding of the safety procedures (Hoffman and Morgeson, 1999). Edvinsson and Malone (1997) and Sveiby (1997) suggest intangible assets of an organization consisting of the immaterial sources of value related to employees' capabilities, competence, skills, organizational and safety culture, the company's image, an organization's resources and way of action and the relationships. It is here that safety knowledge, and its management within the enterprise, conceived of in the broad sense of knowledge that simultaneously impacts the operational, socio-technical and human dimensions of organizational performance becomes the essential management resource in achieving an effective SMS. Thus, in the field of OH&S, this multidimensional and multifaceted knowledge, based on an embedded and reflexive understanding of the challenges posed in establishing a vibrant safety culture at all levels of decision-making in the organization, is the central resource in the achievement of the overall goals of OHSM.

Despite the growing interest in knowledge management (KM) studies, only a few studies (Podgorski, 2010; Sherehiy and Karwowski, 2006, Schulte et al., 2003; Heavin and Neville, 2006) have covered the area of OH&S. Several studies have tried to provide some preliminary evidence of the role of organizational safety knowledge in building safer and healthier workplaces (Gherardi and Nicolini, 2000b; Nuñez and Villanueva, 2011; Podgorski, 2010; Smith-Crowe et al., 2003; Zohar, 1980). In addition, the technical features of OHSMSs are embedded in the social relations of the enterprise but unfortunately little attention has been paid to the socio-cultural and power dynamics of safety culture and knowledge management in the practitioner-oriented literature.

The thesis attempts to create a new ground targeted to recalibrate the importance of sociological and cultural dimensions to safety management analysis.

### Research Problem

The research literature discusses several approaches to developing a positive safety culture and possibilities to enhance it. At the same time, relatively little is known how organizations influence and deal with the formation of safety culture with respect to KM and about the role of tacit and explicit knowledge in the OHSMSs.

Despite multiple attempts to explain safety culture through competing models, there is limited empirical research to substantiate which company values, safety KM and organizational safety practices have the most demonstrative impact on safety performance at the enterprise level. There is potential for organizations to learn, adopt and apply best practice, knowledge and information in the area of OH&S from other companies and various state authorities (Järvis and Tint, 2008). However, deeper understanding of different indicators/aspects of safety culture are required to properly manage and exchange safety knowledge in SMEs because proper KM is essential for the effective OHSMSs, as advocated by many researchers (Podgorski, 2010; Ajmal, 2009). In the light of the above arguments the present study areas under exploration are connected to several theoretical disciplines (see Figure 1). Focus is on how safety knowledge is managed at the enterprise and state level as a part of SMS and at the same time the focal point of the research is also safety culture.
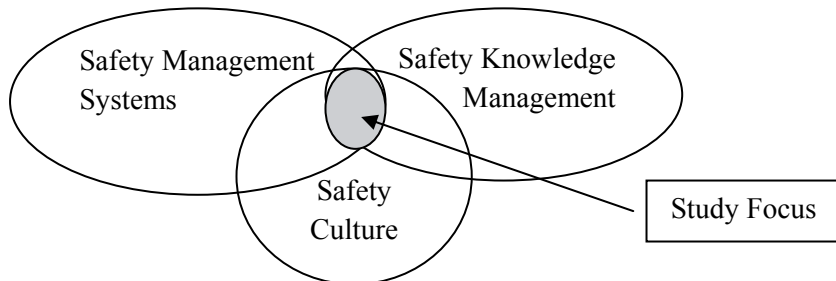


Figure 1. Conceptual framework under exploration (Source: compiled by the author)

Thus, the *aim* of this doctoral thesis is to enhance the understanding of the role and importance of knowledge management to safety management systems as a tool for improving safety culture in Estonian SMEs.

With an inherited low level of workplace safety culture from the Soviet era, and the following 20 years of independence and the establishment of a market economy, there is a need to assess scientifically the degree of compliance of Estonian enterprises with wider European standards of OH&S and what kind of potential and actual barriers prevent acquisition of a positive, sustainable and dynamic safety culture in SMEs, which have been a traditionally challenging sector of the economy for successful OHSMSs implementation.

The topic of the doctoral dissertation combines the public policy areas of employment and social affairs, strategic and managerial approaches in the field of OH&S, focusing on OHSMSs, safety culture and KM at both the level of state policy and the practice of individual enterprises, as well as employers' and

employees' attitudes and understandings of their working environment and its implications for their health, safety and well-being.

For this purpose, the study applies theoretical and empirical evidence in examining the research questions. Detailed objectives are described in the following set of ***research questions*** to be answered in the study. Main research question:

- *What characterizes safety culture and how is it associated with safety knowledge management within the Estonian manufacturing small and medium-sized enterprises?*

The sub-research questions of the study are formulated as follows:

1.  Sub-question 1: *How is safety valued, appreciated and practically realized in the investigated enterprises and what characterizes safety culture within the Estonian small and medium-sized manufacturing enterprises?*

2.  Sub-question 2: *What characterizes safety management systems (within the Estonian small and medium-sized manufacturing enterprises) and what kind of changes in the field of occupational health and safety occurred in the context of Estonian accession to the European Union?*

3.  Sub-question 3: *How do safety management systems reflect one of the major factors – safety knowledge within the Estonian small and medium-sized manufacturing enterprises?*

4.  Sub-question 4: *Which are the enabling and inhibiting factors that will foster the safety knowledge exchange within the small and medium-sized manufacturing enterprises?*

Each of the sub-questions is examined in the seven separate articles. The results of the articles are summarized in Chapter 3. With regard to the main research question, the findings are discussed in the conclusion of Chapter 4.

In order to examine the research problems and to set the direction for this thesis, the following *core research tasks* have been identified:

- To conduct research in Estonian manufacturing SMEs in order to explore the differences between formal safety and real safety and to assess how safety goals and practices are realized practically as an organizational value.

- To investigate existing advantages and shortcomings in the present OH&S system at the national as well as enterprise levels in the context of Estonian accession to the European Union.

- To assess manufacturing employers' and employees' opinion and their perceptions towards OH&S within organizations in order to develop a better understanding of safety culture.

- To outline the application of safety culture and SMSs within manufacturing SMEs.

- To develop and to discuss a possible innovative conceptual model for the improvement of safety culture consisting of KM dimensions that incorporate both tacit and explicit safety knowledge and understandings based upon 'communities of practice'.

- To make further research proposals and explore theoretical and practical implications.
- To provide recommendations for effective safety management and operational practice for OH&S authorities based on the empirical outcomes of the research.

**Research method**

The philosophical basis of this study is (social) constructivism, which sees the culture as a socially constructed concept with a multi-dimensional nature and provides an understanding of the concept of (safety) culture.

The current research is explorative and aims at providing understanding of the contemporary SMS in the organizations. It discovers and captures realities about SMSs within the context of industrial SMEs by focusing on safety culture elements. Inductive research was conducted using qualitative case study approaches to explore the issues based on social constructivism.

The research method of the present study is important because of a general lack of case studies and qualitative research about safety culture and safety knowledge management. Glendon (2008) emphasized the fact that few to none published studies of safety culture apply qualitative methods. This research is an attempt to fulfil this gap and apply an interpretive approach using both qualitative and quantitative methods in order to provide a few systematic conceptualizations on how safety is valued and managed, as evidenced by leadership and employee behaviors and attitudes and performance management systems with a special focus on safety knowledge management. The study applied triangulation forms related to the data (cross-checking information by using multiple empirical sources) to multiple methods of data collection (mixed methods) and data analysis (several researchers examined the materials).

The empirical study of the dissertation was conducted in eight Estonian SMEs operating in different economic sectors in order to clarify how safety is valued and managed and how SMEs reflect and manage the major factor in SMSs – safety knowledge. The field visits took place during the period from April 2009 to October 2009. The most important research methods were semi-structured interviews with senior managers and safety managers (16), eight focus group interviews with employees, several on-site observations and evaluation questionnaires. Supplementary methods were analysis of numerous health and safety documents, media analysis, audits and risk assessment, which complement and verify the data collected during the interviews. In addition, companies' strategy, policy, values, vision and mission statements were investigated based on the data available from their homepages.

Quantitative methods were applied in order to explore employers' and employees' attitudes, perceptions regarding health and safety, values, information dissemination, risk awareness and employees' involvement. The data were acquired from a national Work Environment questionnaire survey conducted by Statistics Estonia in 2009, which is a representative survey

utilizing employer-employee-linked data, designed specifically to study the working environment and to measure safety climate, safety attitudes, perceptions, values, conflicts and relationships, information dissemination, job satisfaction, responsibility and commitment, risk awareness, working conditions, and safety measures. The current survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. A special feature of the survey is that it is first linked the data set of both employees and employers in SMEs exploring *inter alia* issues of employees' involvement, representation, responsibility for workplace safety and health, employers' commitment to safety; importance and relevance of the safety requirements and procedures, training and information; how safety is valued and appreciated throughout the investigated organizations. In addition, *Article IV* describes the results from the comparative (longitudinal) studies of OH&S professionals conducted in 2002 and 2009 (both self-reported data).

The doctoral thesis provides an *original contribution* both at the theoretical and practical level as follows:

1. The study increased understanding of the current OH&S system and of the changes that occurred in this field in the context of Estonian accession to the European Union. This study of a national-led intervention in OH&S policy evaluation and implementation illustrates the limitations and possibilities of disseminating national level strategic understandings to enterprise levels. The author proposes several recommendations for the improvement of the OH&S system (*Articles I; II; IV*).
2. The study provides important empirical evidence on how SMEs address OH&S. Differences in the assessment between 'formal' safety and 'real' safety in Estonian SMEs from different industries are presented, indicating some important safety flaws and drawing attention to contextual variables in the development of SMSs and improving the safety cultures (*Articles II, III, V*).
3. The study provides conceptual clarification on the role of knowledge management in the field of OH&S and, in particular, for safety culture (*Articles V, VI*).
4. The main contribution of the study is a developed and empirically tested innovative conceptual Model of Safety Culture with Knowledge Management Dimensions that incorporates both tacit and explicit safety knowledge and understandings based upon "communities of practice." The model as an effective management tool for assessment and promoting a viable and sustainable safety culture allows an in-depth study of the management of safety knowledge and can assist in the on-going analysis and implementation of a positive safety culture. In addition, the model takes into account the dynamic interrelationships

between safety climate, safety management systems, safety behavior and motivational strategies to create, transfer and utilize safety knowledge within a community of practice at the enterprise level (*Articles IV- VII*).

5. The thesis contributes to theory by proposing a possible approach to improve the safety culture – through managing the safety social capital inherent in an organization. This study has first applied intellectual capital principles to the field of OH&S in Estonia, with a special focus on the knowledge management system as an umbrella for capturing a range of organizational concerns towards health and safety (*Articles V, VII*).

6. The thesis has opened new research perspectives in the field of safety management systems and safety research, especially on the management of psychosocial risk, as well as for health and safety promotion within the enterprises, by focusing on the incorporation of health and safety knowledge as related to a set of core values in safety culture results in the framework for developing a health and safety culture including social capital (*Article V*)

7. The study contributes to providing conceptual clarification on the incorporated conflict management as a learning instrument and its possible effect on safety culture and for knowledge exchange. In addition, the study investigates relationships between employers and employees, co-workers, co-worker peer support and personal responsibility for safety, which has been sparsely reviewed in the scientific literature (Frazier, et al., 2013; Fernández-Muñiz et al., 2007; Flin et al., 2000; Harvey et al., 2002; Geller, 2001).

8. In terms of safety culture research, the study focuses on the often neglected area of the implementation of organizational safety culture. Moreover, this was a multiple case study allowing cross-case comparisons, providing a more comprehensive understanding of the phenomenon studied than the single case studies or safety climate questionnaires commonly used in this research area (*Articles V-VII*). The study contributes to the methodology of the evaluation of the safety culture by applying quantitative approaches ('perceptual measurement-individual attribute approach', which captures organizational safety climate through perceptions of individual attributes) and a qualitative approach (case study, interviews, observations, audit and risk assessment, document analysis), which allows the capture and analysis of organizational, behavioral and psychological aspects of safety culture.

The practical concern of this thesis is to improve OH&S in Estonia with a special focus on SMEs. The thesis identifies commonalities in the need to improve the contribution of safety knowledge to safety management processes and practices in a selected sample of Estonian SMEs in different economic sectors, suggesting that while there may be some variations between sectors in

the application of safety knowledge, further economic benefits and improvements in employee well-being could be secured across all sectors reviewed by creating the appropriate conditions in which to embed a sustainable safety culture in enterprise management systems.

Through the author's views and suggestions, this thesis also attempts to enhance employers' and employees' awareness and public attention towards weaknesses in the relevant Estonian occupational health and safety system, challenges in OHSMSs, unsafe working conditions and acts, and to boost the implementation of the relevant regulations and labour legislation in SMEs. The results from the current research could be useful for safety and strategic management researchers' studies in SMEs as well as for lecturers, students, occupational health and safety professionals (i.e. occupational physicians, hygienists, ergonomists, etc), and safety managers at the enterprises, as well as for decision-makers at the sectoral organizational and state level.

The *originality* of the studies lies in the usage of the data from a small open economy of Central and Eastern Europe, the Baltic state of Estonia. The thesis provides an insight into the necessary mix of regulation and self-regulation in the management of OH&S at the enterprise level and into the balance between the two required to achieve effective and sustainable safety cultures in an economy dominated by SMEs. It thus has potentially wider applications in the area of OH&S.

The thesis is a collection of seven original publications that deal with the research question and key concepts as outlined. The current thesis is divided into three main chapters. Chapter 1 presents the theoretical framework for the study. The materials and methods used in this research are described in detail in Chapter 2. Chapter 3 presents the main results and applications, followed by a summary and discussion of the main conclusions of the seven articles presented. Further research avenues are suggested and the study's limitations are also discussed.

**Overview of the approval of research results**

Results from all surveys included in the present thesis have been published and presented by the authors at international scientific conferences, following the acceptance of peer-reviewed submitted abstracts.

- The study results concerning empirical examination of the relationships between different aspects of safety culture based on an innovative conceptual model for the improvement of safety culture with a special focus on the management of safety knowledge were presented by the author at the Riga Technical University 54th International Scientific Conference, Latvia, in October 2013.
- The study results concerning differences between formal and real safety and the theoretical framework for applying the concept of Intellectual

Capital and 'Communities of Practice' as one of the main ways of knowledge transfer in the field of OH&S, were presented by the author at the 'International Conference in Occupational Health and Safety: From Policies to Practice', Riga, Latvia, in December 2012.

- Results from the assessment of possible occupational hazards in Estonian SMEs from different branches of industry, assessment of companies' safety management systems and assessment of how this practice has developed in the context of Estonian accession to the EU, were presented by the author at the European Conference on Health Economics (ECHE), Helsinki, Finland, in July 2010.
- Results from the study concerning auditing of the safety management system in Estonian medium-sized enterprises and analysis of the results from the qualitative study were presented by the author at the International Conference 'Insights into the Sustainable Growth of Business', Vilnius, Lithuania, in November 2009.
- Based on the theoretical literature concerning safety culture and knowledge management systems, the author developed conceptually innovative models for the improvement of the safety culture consisting of knowledge management dimensions. The introduction of the augmented Cooper's Reciprocal Model of Safety Culture with Knowledge Management System Dimensions was presented by the author at the ESREL (European Safety and Reliability Association) Annual Conference, Prague, Czech Republic, in September 2009.
- Results from the survey concerning safety knowledge transfer at the state level and its critical components were presented by the author at the scientific conference HAZARDS XX 'Process Safety and Environmental Protection, Harnessing Knowledge, Challenging Complacency', Manchester, UK, in April 2008.

## Abbreviations

**CoP –** Communities of Practice    **OPs –** Occupational physicians
**EU –** European Union                      **SC -** Social Capital
**IC -**    Intellectual capital                **SME –** Small and Medium-sized Enterprises
**KM –** Knowledge Management       **SMS –** Safety Management System
**KMS –** Knowledge Management System
**OH&S -** Occupational Health and Safety
**NLI –** National Labour Inspectorate
**OHS –** Occupational Health Services
**OHSM -** Occupational Health and Safety Management

# 1.    THEORETICAL FRAMEWORK

*"To be thus is nothing,*

*but to be safely thus"*

William Shakespeare

*(Macbeth, Act III, Scene I)*

## 1.1.    Occupational Health and Safety Management Systems

Managing occupational risks in an integrated way with the organization's operations has become increasingly essential in recent years, since it can positively affect not only accident rates and safety performance of an organization, but also have a positive influence on competitiveness performance and the organization's productivity, economic-financial performance of an organization and on the control of workers' safe behavior (Fernández-Muñiz et al., 2009; Stolk, et al., 2012; O'Toole, 2002).

The scientific literature on occupational health and safety management systems (OHSMSs) often distinguishes mandatory or regulated OHSM from voluntary systems, which clearly distinguish the concept of OHSMSs from the concept of systematic OHSM (Frick et al., 2000; Robson et al., 2007). The most important difference between regulated OHSM and a voluntary system is their goals and structure (Frick and Kempa, 2011). Mandatory OHSM is defined by its outcomes, arises from government legislation and dictates a limited set of core principles for the management of OH&S to be implemented by employers. One example of a mandatory OHSM is Framework Directive 89/391/EEC, which defines employers' responsibilities, requirements and principles on how to manage occupational health and safety (OH&S), such as to evaluate the occupational hazards and conduct risk assessment; to implement relevant safety measures; to provide information and safety training for employees as well as to involve them in OH&S activities. At the same time, voluntary OHSMSs are defined by their means, by the correct introduction and application of their specified procedures. This system contains a large number of specified procedures in a complex structure, is not state-regulated and tends to be more complex than regulatory systems and is more formalized in terms of specifications. Voluntary OHSMSs are described in standards or guidelines that are international (e.g. ILO-OSH 2001) or national (e.g. BS 8800 or EVS 18001:2007). Voluntary OHSMSs require external certification by auditing and certifying organizations, but mandatory OHSM can never be certified. Both OHSM systems have been criticized:  the mandatory regulations for being too bureaucratic and thus at excessively high administrative costs for employers, and voluntary OHSMSs for a narrow content.

Besides OHSMSs, many organizations tried to implement other management systems, for instance for quality and environment. The implementation and certification of quality, environment and OHSM systems have been major activities for many organizations in the light of increasing competitiveness and pressure from their internal and external stakeholders, including the regulatory bodies, community, customers, suppliers, employees, and the government (Zutshi and Sohal, 2005). According to Zutshi and Sohal (2005), integration of systems (Total Quality Management System, TQMS) can save both time and costs for companies. Other benefits of the integration of separate systems (quality, environmental and occupational health and safety management systems) into one operational system (TQMS) have been identified by Bragg et al. (1993); Zutshi and Sohal (2005); White (1999); Owen and Brischetto (2000). For instance, these include a positive influence on strategic planning, resource utilization, acceptance and understanding among the employees, training programs, enhancing communication, auditing and housekeeping as well as better addressing of people-related issues. However, there are some challenges for integrating the management systems, for instance people's attitudes, lack of strategic planning; lack of expertise and use of consultants; continually changing regulation and guidelines; reporting of results, time-delays in integration (Zutshi and Sohal, 2005).

Many researchers have emphasized the benefits of using voluntary OHSMSs to manage and control risk at work mainly for the large scale, multi-site organizations, often from the manufacturing sector (Frick, 2011; Bently and Tappin, 2010; Fernández-Muñiz et al., 2007; Makin and Winder, 2008). According to Makin and Winder (2008, p 935), "transferring these benefits of using OHSMSs to smaller businesses has been fraught with difficulty, with the mechanics and bureaucracy of the system itself sometimes becoming overwhelming".

Despite the benefits of the voluntary OHSMS, this system is not common in Estonia, especially among small and medium-sized enterprises (SMEs), which are the main focus of the current study. According to the author's estimation, at present only a minority of Estonian SMEs (0.2%) have established a voluntary OHSMS (based on national standard EVS 18001:2007). A large proportion (71%) of the SMEs that have established voluntary OHSMSs (Source: Estonian Association for Quality, 2013) are construction enterprises and only 29% are manufacturing SMEs. Therefore, the current study focuses mainly on mandatory or regulated OHSM with manufacturing SMEs.

Safety is a prime example of a critical organizational component that can be studied in relation to safety culture as evidenced by leadership and employees' behaviors and attitudes, performance of management systems, and communications.

Many researchers (Hale and Hovden, 1998; Cooper, 1999; Rasmussen, 1997) have focused on the broadness and complexity of safety culture to illustrate the fact that it does not operate in a vacuum but affects, and in turn is affected by,

other non-safety related operational processes or organizational systems. Schein (1992) claims that the way in which senior managers reward, instruct, allocate resources and their attention as well as behavior under the pressure, will be particularly salient in shaping organizational (safety) culture. Other researchers (Cooper, 2001; Clarke, 1999; Brown and Trevino, 2012) suggested that perceptions of senior managers' attitudes and behaviors in relation to the health and safety, well-being of workforce will form the basis for the safety behavior of employees, and therefore, the safety performance of the organization. In common with most conceptualizations, these definitions emphasize the critical and essential link between safety culture and the OHSMs through shared values and beliefs that guide behavior patterns and health and safety activities in the organization. A strong safety culture is generally considered as a vital condition to well-functioning SMSs (Bently and Tappin, 2010; Fernández-Muñiz et al., 2009).

## 1.2. Safety culture and safety management systems within enterprises

A safe and healthy working environment is an important element of work life quality (Fugas et al., 2012) and many researchers have shown a strong interest in the behavioral aspects of safety, while safety culture and safety climate have become essential cornerstones of modern thought about OHSMs in organizational culture (DeJoy, 2005; Frazier et al., 2013; Rao, 2007). Numerous studies demonstrate that the performance of an organization is dependent on the strength to which the (cultural) values are extensively shared (Ajmal, 2009). One of the strongest challenges for an organization in today's competitive business environment is to create and preserve a self-sustaining safety culture (Rao, 2007). However, there is a need for more research in order to better understand and validate the concept, content and outcomes of positive safety culture on safety performance (Bently and Tappin, 2010; Guldenmund, 2000; Hopkins, 2006). Below safety culture will be explained in detail.

A safety culture (as a sub-unit of organizational culture) has no unique and universal definition (Frazier et al., 2013; Edwards et al. 2013). However, it can be defined as the product of the individual and group values, attitudes, beliefs, risk-perceptions (Lee and Harrison, 2000), competencies, norms, principles, and patterns of behavior that determine the commitment of employees to health and safety, as well as the style and proficiency of an organization's health and safety programmes (The Health and Safety Executive, 2005). It is essential that employees' health and safety behavior as organizational values are adopted and shared between all employees throughout the organization and not only formally existing on paper. Employees' attitudes and safety behavior are based on adopted and recognized values (*See Article V*).

A problem with safety culture and safety climate is that no universal agreement on the definitions of these concepts exists and both have often been

used interchangeably (Høivik et al., 2009). According to Flin (2007), the most widely accepted definition of safety culture is from the nuclear power industry: "the safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's SMs". According to Zohar (1980, p 96), safety climate is a summary of "perceptions that employees share about their work environment" and can also be defined as the perceived state of safety of a particular place at a particular time (Flin et al., 2000; Fleming, 2000). Flin et al. (2000) summarized safety climate as reflecting attitudes, perceptions and beliefs and it may be seen as a "snapshot" of the safety culture, while safety culture is more complex, reflecting values and norms. *Article VI* discusses differences between safety culture and safety climate and concludes that safety culture is expressed through the safety climate in an organization and that safety climate is relatively unstable and subject to changes depending on the features of the operating environment. Safety climate is clearly a sub-component of safety culture related to individual and group attitudes and behaviors related to engagement in safety practices (Cooper, 2000; Fernandez-Muniz et al., 2007).

A literature review shows that very few models of organizational safety culture exist (*See Articles IV and VI*). Guldenmund (2000) claimed that there has been no consensus on the content of safety culture or its effects, and no satisfactory models of safety culture have been developed.

Coopers' model (2000) is used as the framework for the current study upon which to identify the activities associated with the assessment of both SMSs and safety culture. Cooper (2000) proposed a model to reflect the concept of safety culture that contains three elements: internal psychological factors (safety climate), external observable factors – organization (safety management system) and job (safety behavior) (See Figure 2). All elements of this model can also be broken into exactly the same reciprocal relationships, thereby allowing the multi-faceted nature of the safety culture construct to be systematically evaluated as by Cooper (2000).

An important aspect is that Cooper (1999, 2000) considers SMSs as environmental factors in his model of safety culture. This is due to the fact that organizations are contained entities, where the efficacy of the SMS is the key internal environmental factor. However, since safety culture is the dynamic reciprocal relationship between members' attitudes and perception toward safety, there is the presence of external influences including relevant legislation, history, economical and safety climate. An internal environmental factor is a SMS and an external one: norms, government policies, regulations, economic climate and situation (Ismail et al., 2012).
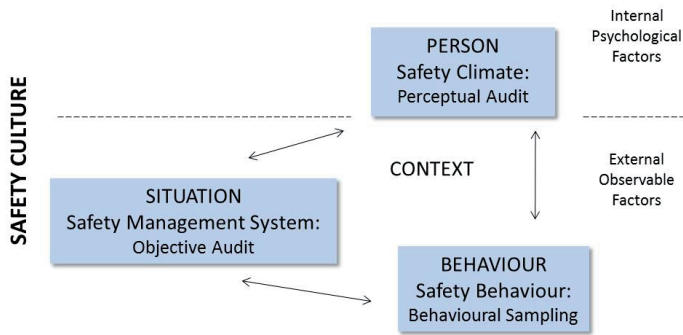
Figure 2. Reciprocal safety culture model (Cooper, 2000)

Many companies want to enhance their safety culture or some aspect of safety behavior and to find enhanced ways forward. It is clear that organizational safety through technical design and management of physical or tangible resources/assets, such as safer technology, regular audits and proper risk assessment; use of less hazardous chemicals and the elaboration of safe procedures, safety policies and guidelines, is relevant but obviously it is not sufficient. In the context of the OHSMs, special attention should be paid to intangible resources/assets of an organization obtained through human safety experience and practice in the workplace.

## 1.3.    Knowledge Management System in Occupational Health and Safety

Organizations are recognizing that one of their most valuable resources is knowledge. In the literature on knowledge management (KM), one of the vital research questions is the impact of KM initiatives on business performance when the competitive potential of the total quality management system and business process re-engineering had been exhausted (Podgorski, 2010). Davenport and Prusak (1998) have proposed the following definition: "Knowledge management draws from existing resources that your organization may already have in place – good information systems management, organizational change management, and human resources management practices". From the definition of KM it is clear that any advancement in this field needs to adopt an integrated (Davenport and Prusak, 1998), interdisciplinary and strategic perspective. According to the literature, the KM principles applied have led to an improved effectiveness of an environmental management system (Huang and Shih, 2009). However, only a few studies (Podgorski, 2010; Sherehiy and Karwowski, 2006, Schulte et al., 2003; Heavin and Neville, 2006) have covered the area of KM related in particular to the OH&S (Järvis et al., 2008).

Knowledge has been recognized as a new resource in gaining organizational competitiveness and it is also the central resource in the achievement of the goal of OHSMSs. Sherehiy and Karwowski (2006) also suggested that the principles and tools of KM should be used to facilitate the management of the existing

individual (personal) knowledge, structural knowledge (i.e. knowledge codified into manuals, reports, databases, and data warehouses), and organizational knowledge (activity of learning within the organization) in the fast domain of practical application. Organizational KM in the field of OH&S treats a mixture of two kinds of knowledge: tacit knowledge and explicit knowledge. Explicit knowledge, sometimes referred to as a codified knowledge, is objective knowledge that can be transmitted in formal, systematic language (Jacobson, 2006.). An example of explicit knowledge on OH&S consists of governmental and local regulations, standards, norms, and safety requirements, which are stored as written documents or procedures. According to Sherehiy and Karwowski (2006), explicit knowledge in the area of OH&S is accident records, safety regulations, safety guidelines, theories and axioms, and company records. In the context of the management of OH&S, special attention should be paid to tacit knowledge, because the research topics are often identified through direct human experience in the workplace, and the results of the research are often immediately applicable to the solution of a problem. Examples of tacit knowledge are: safety engineer's experience, safety hazard recognition related to practical aspects, perceptual and cognitive skills, physical experiences, rules of thumb and synthesis of facts (Sherehiy and Karwowski, 2006). In addition, in the context of an OH&S management system, examples of tacit knowledge include the individual knowledge of the experienced worker and specialist, as well as estimating and tendering skills acquired over time through hands-on experience, understanding the technological process, interaction with clients/customers, awareness of occupational hazards and possible health effects, prevention measures, their responsibilities and rights. This type of 'ground-level' tacit knowledge is experiential, judgmental, context-specific and therefore difficult to codify and share (Järvis and Tint, 2008; Podgorski, 2010.).

Safety knowledge can be conceptualized as an employee understanding of the safety procedures (Hoffman and Morgeson, 1999). Based on this theory, individuals should be motivated to participate in safety activities and have knowledge on safety procedures if they perceive a positive (supportive) safety climate. Further, if individuals perceive the intrinsic value associated with safety and have knowledge on the safety procedures, they will be less likely to have workplace accidents. These findings have been supported in a number of studies (Gherardi et al., 1998; Griffin and Neal, 2000; Neal et al., 2000).

An essential characteristic of knowledge is that it only generates value for the organization when it is used effectively (Seemann et al., 2002) and shared (Järvis and and Tint, 2008). Although knowledge sharing and knowledge transfer are often used interchangeably, knowledge sharing refers to exchange of knowledge between two individuals and focuses on human capital. This is the realm of tacit safety knowledge. By contrast, knowledge transfer focuses on structural capital and the transformation of individual knowledge to group or organizational knowledge, which becomes a built-into process, products and services (Jacobson, 2006). An understanding of the process of creating

organizational knowledge how explicit and tacit knowledge are exchanged and utilized is the basis of KM at the enterprise and state level. The process of KM and knowledge transfer at the state level in Estonia was analyzed in recent years (Järvis and Tint, 2007) and the main ways of knowledge transfer in the field of OH&S are via Communities of Practice (CoP), the internet and training. However, little is known how employers, workers and OH&S professionals receive, analyze, share and use this information.

Organizational knowledge (also known as organizational memory) is a social and collective phenomenon and may be based on the notion of practice (Gherardi and Nicolini, 2000) resulting if the learning is conducted within a given organization (Podgorski, 2010). Workplace safety is a form of organizational expertise, which can be viewed as a situated practice, an emerging property of a social-technical system, the result of a collective process, a 'doing' which involves people, interaction, technologies as well as social relations (Gherardi and Nicolini, 2002a,b; DeJoy et al., 2010; Wiegmann et al., 2004). It is therefore situated in the system of on-going practices that has both explicit and tacit dimensions (*See Articles IV-VI*).

Organizational learning is a process during which the organizations share, create, spread, and expand their knowledge, connecting from groups to organization (Chang et al., 2006; Jashapara, 2011). This is also a tool for the development of a CoP and potentially gives a possibility for employees to exchange explicit and tacit knowledge (*Article V*). Wenger (1998) provides a theoretical basis for CoP and describes it as an evolutionary process for learning in groups. In addition, CoP comprise everything that its members in the organization negotiate or produce (Wenger, 1998), which also includes symbols, technology, textual and symbols in a ''system of material relations'' (Gherardi and Nicolini, 2000). According to Hislop (2005), a CoP is realized in informal groups of people who have a particular activity in common, and as a consequence have some common values, knowledge, and a sense of community identity.

Based on the sociological view of learning, individuals in organizations continuously obtain, combine, modify and use knowledge through their everyday cooperation and interaction (Chang et al., 2011; Jashapara, 2011). Nahapiet and Ghoshal (1998) have stated that organizations have potential and capabilities for developing, creating, sharing and utilizing knowledge and intellectual capital (IC), and the development and cultivation of social capital (SC) are likely to realize a competitive advantage. Roos et al. (1997) conceptualized IC as the sum of all intellectual materials – knowledge, information, intellectual property, skills, experience and knowing capabilities of companies – that can be combined and utilized for competitive advantage. Knowledge development in an organization is dependent on and influenced by the organization's SC (Davenport and Holsapple, 2006). Therefore, the organization encourages the development of SC and, hence provides possibilities and creates a structure for sustained interaction, conversations, socialization,

teamwork and cooperation between its members in order to create the new IC and knowledge.

The focus here is on the application of intellectual capital principles to the field of OH&S with special emphasis on the KM system as an umbrella for capturing a range of organizational activities in order to manage the integration of human, structural and social capital, thus enhancing learning and performance in an organization (See Figure 3).
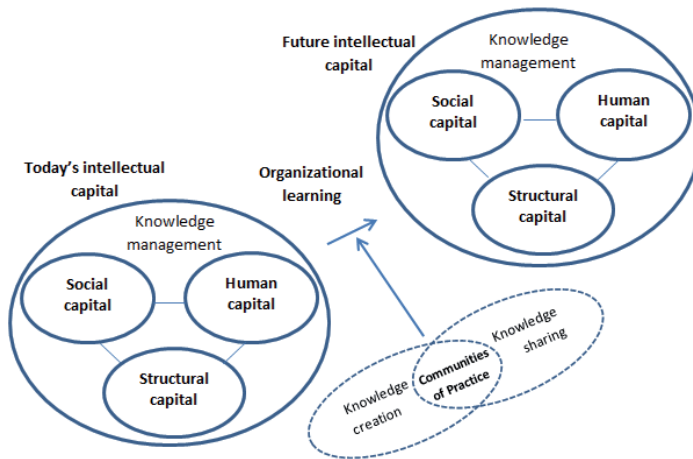


Figure 3. Intellectual capital grows with use and requires organizational learning (based on Seemann, et al. 2002)

## 2.      METHODOLOGICAL APPROACH

Methodology is constructed on the researcher's philosophical knowledge concepts. It means that methodology uses the researcher's ontological and epistemological concepts to outline the research strategy and methods (Keso et al., 2009). According to Eriksson and Kovailainen (2008), ontology concerns the ideas about what (knowledge) exists in the world; existence of interpersonal social relations and what the existence of societies is based on, and how they are formed and transformed. Epistemology in scientific research means certain criteria for research knowledge and it defines how knowledge can be produced and argued for (Eriksson and Kovailainen, 2008; Virta, 2011). The ontological position of this study is to consider the phenomena being researched, namely exchange of safety knowledge and safety culture, as social structures or constructions, which are constantly shaped by a variety of actors working in these fields. Therefore, knowledge about these phenomena, i.e., the epistemological standpoint for this study, is available through creating an insight by interviewing employers and employees.

The research phenomenon (safety) culture is shaped by its members to provide a meaning of what is the value and what is important in the organization. It defines what people value and how they act. In axiology, as the overall theory of values, it is possible to distinguish two disciplines dealing with certain kinds of values – ethics and history of philosophy. Ethics is concerned with the analysis of ethical values, ethical decisions, acts and attitudes. History is a tool not only for remembering the past but also for shaping and understanding the present. In the analysis of an enterprise (safety) culture, tradition, history is important. Every industry and enterprise shapes its values and culture in a historical context. Therefore, it is essential to have the knowledge of history of forming the safety. An axiology of safety culture is an analysis of the practices, symbols, values, beliefs, and other cultural forms that have evolved with the issue of safety. In addition, the other research issue is safety knowledge as a value in the organization, the possibility (social interaction, organizational structure) to exchange tacit and explicit knowledge. This is the axiology and it is what motivates people to interact and to develop the awareness of individual employees and managers on occupational hazards and risks in order to to improve safety culture and to learn.

## 2.1. Constructivism

Philosophy of science refers to world views and ways of thinking related to understanding the nature and development of knowledge and reality. There are three important views about the research process that dominate in business and management research: positivism, interpretivism and realism (Saunders et al., 2003). Organizational (and safety) culture studies have been dominated by two main paradigms: functionalism (Schein, 1992; Guldenmund, 2007) and interpretivism (Antonsen, 2009; Alvesson, 2001, Richter and Koch, 2004).

According to Antonsen (2009), there has been a shift in perspectives, from a functionalist perspective towards a more constructivist view of culture. Most researchers of organizational (safety) culture see culture as both a product and a process structuring behavior (Antonsen, 2009). Following the functionalist approach, culture is viewed as a critical variable that influences, for example safety and reliability and safety culture is often understood as shared patterns of behavior: 'the way we do things around here' (Hofstede,1994; Reason, 1997; Nævestad, 2009, Cooper, 2000). However, other researchers (Alvesson, 2002, Schein, 2004; Haukelid, 2008) of culture in organizations demonstrate that also shared patterns of meaning motivate and legitimize actions (Pidgeon, 1998; Haukelid, 2008). Functionalist safety culture research has mainly been conducted with quantitative methods.

Several researchers (Pidgeon, 1998; Richter and Koch, 2004) argue that the field of safety culture needs to be studied by the interpretive approach. According to interpretive researchers, the culture is conceived as a metaphor for the organization, and 'the meaning aspect of all organizational phenomena'

(Nævestad, 2009). Interpretive safety culture researchers understand culture as shared patterns of meaning that members of organizations draw on as they interpret their beliefs, collective identity and behavior (Alvesson, 2002; Glendon and Stanton, 2000) and is created through group members' interaction (Richter and Koch, 2002; Gherardi and Nicolini, 2002a).

Safety culture is shaped by people in the structures and social relations within and outside the organization (Richter and Koch, 2004; Høivik et al., 2009; Haukelid, 2008).

*The present research philosophy is an interpretive approach.* This is one of the main approaches to conceive the relationship between culture and safety (Nævestad, 2009). However, some interpretive studies of safety culture were criticized by Turner (1992), Reiman and Oedewald (2007) because of a lack of a proper conceptualization of the relationship between culture and technology in high-risk organizations. In order to study safety culture (as patterns of meanings), the use of qualitative methods is most appropriate. Glendon (2008) emphasized the fact that few to none published studies of safety culture apply qualitative methods. The current research is an attempt to fill this gap and apply an interpretive approach using both qualitative and quantitative methods in order to provide systematic conceptualizations on how safety knowledge is managed as an antecedent of safety culture.

The work of Gray and Thomas (2006) served as the theoretical orientation for this study - constructivism, which sees culture as a socially constructed concept, multi-dimensional in nature and provides an understanding of the concept of culture. This modern anthropological perspective rejects a static view of culture, but instead emphasizes its dynamic, multifaceted, and lived nature that varies among different individuals (Kleinman and Benson, 2006). Underlying it is *social constructivism* (learning theory with strong epistemological elements), which emphasizes the importance of (safety) culture and context in understanding what occurs in society and constructing knowledge based on this understanding. Social constructivism is a sociological theory of knowledge, according to which social reality is being constructed through human activity. Learning is a social process and it occurs when people are engaged in social activities, team work, when they come together in order to solve problems, in our case, in the field of OH&S.

*The current study applied hermeneutical methodology*, since "the variable and personal nature of social constructions suggests that individual constructions can be elicited and refined only through interaction between and among investigator and respondents" (Guba and Lincoln, 1994, p 111). In addition, hermeneutics is a methodology that seeks to develop meaning by exploring the context by using known (retrospective) elements of the cultural and social environment surrounding the event or experience to which the narrative relates. The current methodology could be useful for instance in looking for insights from accidents reports and other health and safety documentation particularly

with emphasis on cultural and social impacts on the development of the OH&S system in a historical context (at the enterprise and state levels).

The research uses both deductive (theoretically based) and the more inductive (empirically based) research models. Deductive research builds models, sets hypotheses based on the theory and tests them on quantitative empirical data. Qualitative data are used more empirically based, with the theoretical framework as the starting point (Eriksson and Kovalainen, 2008). According to the research process and Eriksson and Kovalainen (2008), the model could be termed abductive. Abduction is a form of logical inference that goes from observation to a hypothesis that accounts for the reliable data (observation) and seeks to explain relevant evidence. Abduction is intended to help social research, to be able to make new discoveries in a logically and methodologically ordered way. Abduction is the logic used to construct descriptions and explanations that are grounded on the everyday activities, as well as on the language and meanings used by social actors.

## 2.2. Research strategy

*The scientific research strategy adopted in the present study is a qualitative case study.* The particular research strategy was chosen because the behavior of a group and an individual was studied and the safety culture was treated as a contextual, situational phenomenon.

Since OH&S is a multidisciplinary and complex field embracing organizational studies and applied research, the present study aims to achieve methodological triangulation through a combination of exploratory (case study, survey) and comparative (longitudinal) studies. The present study applied triangulation forms related to the data (cross-checking information by using multiple empirical sources); to multiple methods of data collection (mixed methods) and data analysis (several researchers examined the materials). The combined methodology therefore uses triangulation to increase reliability where the major approach is qualitative and supportive is a quantitative approach (See Figure 4). A descriptive multi-method approach was adopted because the research questions required a variety of approaches. *Inductive research was conducted using qualitative case study approaches to explore studied issues based on social constructivism.*

The aim of the qualitative data analysis is to create clarity and thus new knowledge of the focus of the research. Quantitative, deductive research complements and improved answers are given by the qualitative study approach, for example, a safety culture is statistically described and interpreted with numbers. The thesis made an attempt to combine the deeper insights of qualitative methods with some more quantifiable data. The qualitative case study was used in addressing '*what', 'how'* and *'why'*– questions (Yin, 1994; Voss et al., 2002; Saunders et al., 2003; Flin et al., 2000; Bently and Tappin, 2008). This study makes use of a qualitative approach in order to investigate rich real-

life organizational context, which allows studying the complexity of factors (safety culture; SMs (focused on social, organizational and behavioral perspectives) – as they are related to workers, their behavior and interactions with the SMs of the organization. Qualitative research aims at building a topic specific theory built upon certain empirical data. Based on the goal of the research, qualitative research can be particularly useful for such an approach because its sensitivity to the context provides opportunities to build fully meaningful points of studied phenomena.
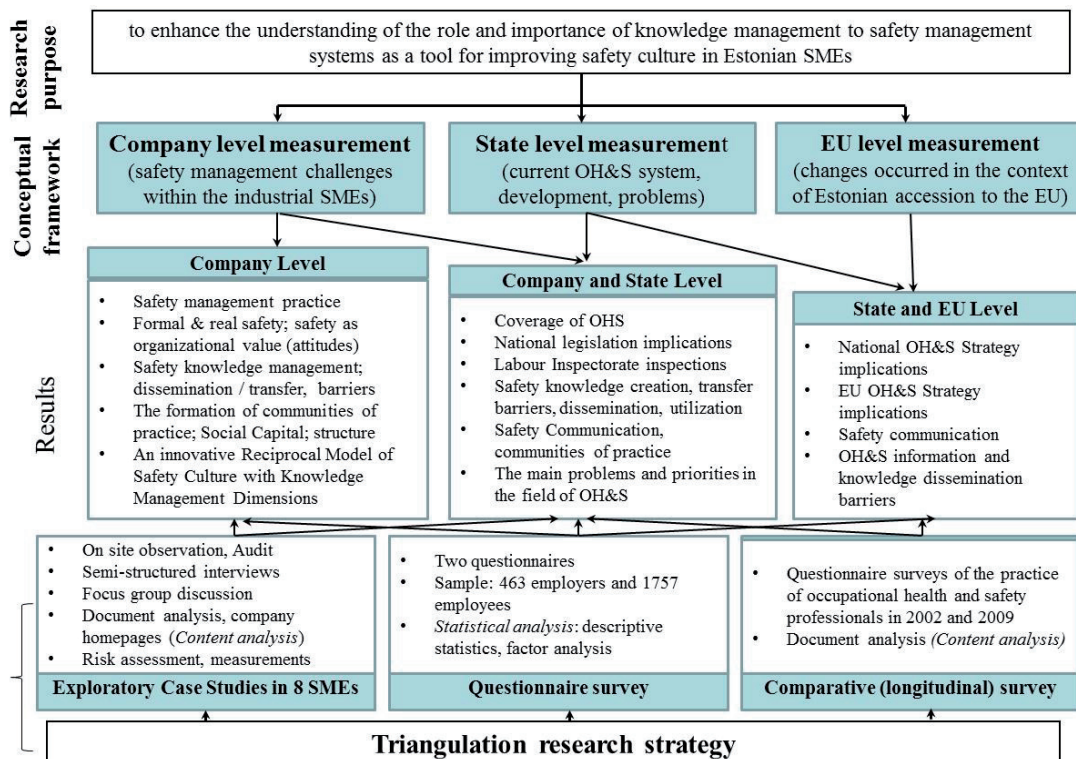


Figure 4. Objectives and concepts of the research project (Source: compiled by the author)

Moreover, a quantitative approach is also appropriate for the present study in order to recognize factors that influence safety culture in the organization, to measure employee and employer attitudes and perceptions towards health and safety. Quantitative methods were used to develop a theoretical model of safety culture with knowledge management system dimensions and to test it. As such, it is suggested that there is a benefit of combining both quantitative and qualitative approaches (Bryman, 2006). All these considerations show different angles as to why both approaches are suitable for the purpose of this study.

## 2.3. Research methods and data collection

The current study consists of seven scientific articles, each looking at the subject under study from different point of view (See Figure 5).
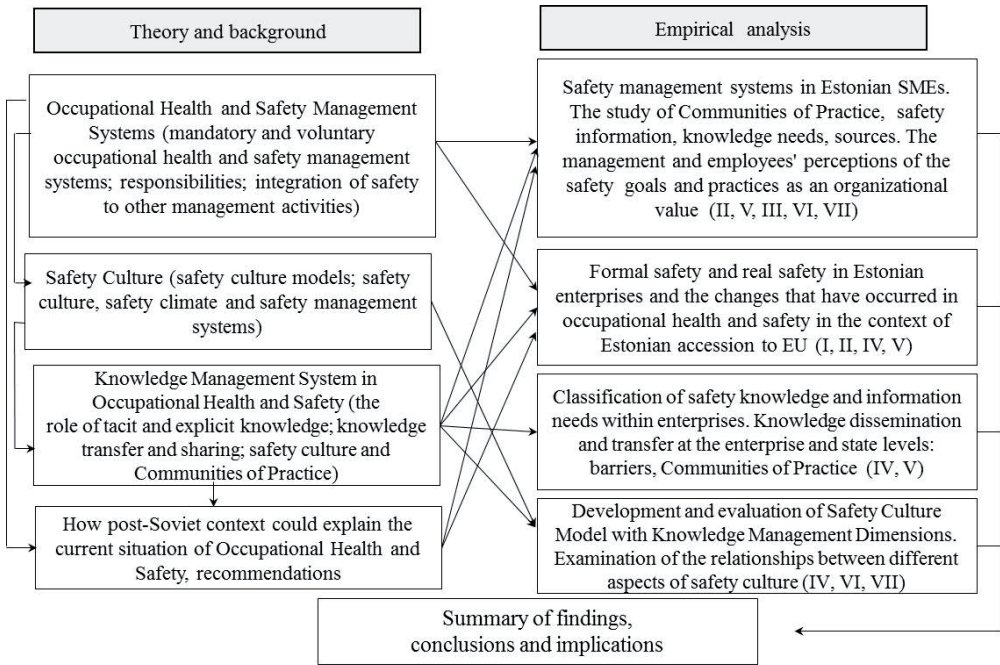


Figure 5. The theory and background and empirical analysis of the thesis study (Source: compiled by the author)

In this research, several research methods and information sources have been used. The empirical study was conducted in eight Estonian SMEs from different branches of industry. The most important research methods were semi-structured interviews with senior managers, focus group discussions with employees, health and safety documents analysis, audits and evaluation questionnaires. Supplementary methods were on-site observations, risk assessment, media and company homepage analysis. Besides that, the data for this study were acquired from a national Work Environment questionnaire survey, conducted by Statistics Estonia in 2009, which is a representative survey utilizing employer-employee-linked data, designed specifically for working environment studies and safety climate measurements.

Table 1 summarizes the research design in terms of the objectives, methodology and the data used in the publications.

Tabel 1. Summary of the articles (Source: compiled by the author)

| Publication | Objective | Methodology and data | Conclusions and Contribution |
|---|---|---|---|
| **I** Risk Observatory-A Tool for Improving Safety and Health at the Workplace | To explore the working conditions, ways in which to manage risks. To examine the role of NLI risk observatory in safety knowledge sharing and transfer and explore the main changes and problems in the OH&S | *Qualitative:* case study, observation, flexible risk assessment method and measurements of occupational hazards in two firms; document analysis (NLI's assessment reports, changes in priorities and strategies of inspection) | Increased understanding of the current OH&S system. This study of a national-led intervention in OH&S policy evaluation and implementation illustrates the limitations and possibilities of disseminating national level strategic understandings to enterprise levels. Several recommendations for the improvement of the OH&S system are presented. |
| **II** The formation of a good safety culture at the enterprise | To examine the working conditions and possible occupational hazards in the selected SME and to analyse SMSs and to explore employees' and employers', health and safety specialists' awareness about OH&S, practices and changes that occur in the field of OH&S in the context of Estonian accession to the EU | *Qualitative:* case study, document analysis, interview data from six SMEs, observation, flexible risk assessment method, measurements of occupational hazards, audit by modified Diekemper & Spartz method; *Quantitative:* a sample of 412 employees (2002/2004) and 41 OH professionals; 422 employees in 2008) | Increased understanding of the changes occurring in the field of OH&S in the context of Estonian accession to the EU; on SMEs' SMSs and how safety is valued and practically realized in the investigated enterprises. A complex approach to the management of OH&S issues is proposed with possible tools – simple computer-based applications to identify occupational hazards. |
| **III** Risk Assessment and Measurement of Hazards in Estonian Enterprises | To explore safety in SMEs (to investigate the working conditions and the possibilities to improve SMSs). To explore safety knowledge sharing and transfer at the enterprise level | *Qualitative:* case study, document analysis, observation, flexible risk assessment method and measurements of occupational hazards in 18 SMEs from six industries | Providing knowledge on the *real* safety (working conditions) in the manufacturing SMEs and measuring control risks. Increased understanding of the ways for safety knowledge exchange within the enterprises. Providing conceptual clarification on SMSs. |

| Publication | Objective | Methodology and data | Conclusions and Contribution |
|---|---|---|---|
| **IV** Innovations at workplace: an evidence based model for SMSs | To explore the link between OH&S and KM and to clarify the concept of safety culture. To propose a model for improvement of safety culture. To evaluate the OH&S professionals' attitudes, their role in the creation of safety culture at the enterprises | *Conceptual; Qualitative:* case study, interview data from seven SMEs, documents analysis;<br><br>*Quantitative:* a sample of 41 OH&S specialists (2002) and 46 in 2009 - two comparative (longitudinal) studies | Providing conceptual clarification on the role of KM in the field of OH&S and, in particular, for safety culture. Developing an innovative conceptual model for the improvement of safety culture consisting of KM dimensions. Increased understanding of the changes occurring in the field of OH&S (2002, 2009) |
| **V** Formal Safety Versus Real Safety: Quantitative and Qualitative Approaches to Safety Culture – Evidence from Estonia | To examine differences between formal and real safety in Estonian SMEs from different industries and to discuss alternative possible approaches to safety culture - through managing the safety social capital inherent in an organization.<br><br>To explore safety as an organizational value, existing safety culture and management of safety knowledge in SMEs. | *Quantitative:* a sample of 463 employers and 1757 employees from ten industries (source: Statistics Estonia, 2009);<br><br>*Qualitative:* case study, interview data from eight SMEs (semi-structured interview with 8 senior managers and focus group interview with 22 workers), document analysis; Media and company homepage analysis | Providing knowledge and important empirical evidence on how SMEs address OH&S. Contributing to the theory of safety culture by analyzing safety social capital and workplace conflicts as a part of culture. Emphasizing the importance of CoP as a source of safety culture and as the 'one important focus of learning and transmitting practical safety knowledge. Contributing to the methodology for evaluation of safety culture by providing knowledge on the essential aspects in the process of evaluation of safety culture. |
| **VI** KM: a neglected dimension in discourse on safety management and safety culture – evidence from Estonia | To propose a model for a positive safety culture with a KM dimension and to test this on a sample of 1757 employees. To explore the possibility of using KM in the discourse on SMSs and safety culture. | Quantitative: a sample of 1757 employees from ten industries (source: Statistics Estonia, 2009) | Presenting an innovative conceptual model for the improvement of safety culture with a KM dimension. Providing knowledge on the relationships between safety climate and safety culture using the proposed model as an effective assessment tool for the evaluation of KM dimensions of safety culture. |

| Publication | Objective | Methodology and data | Conclusions and Contribution |
|---|---|---|---|
| **VII** Managers' perceptions of organizational safety: implication for the development of safety culture | To examine the relationships of different aspects of safety culture and SMSs as well as to explore senior managers' and employees' perceptions and attitudes to safety.<br><br>To test the proposed positive safety culture model with a KM dimension. | Quantitative; a sample of 463 employers and 1757 employees from ten industries (source: Statistics Estonia, 2009);<br><br>*Qualitative*: case study, interview data from eight SMEs; semi-structured interview with eight senior managers and focus group interview with 22 workers), document analysis, observation | Providing knowledge on the relationships of different aspects of safety culture, through a KM dimension with a special focus on safety knowledge management.<br><br>Providing conceptual clarification on incorporated conflict management as a learning instrument and its possible effect on safety culture and for knowledge exchange. |

Reviews of safety culture surveys identified a large variety of different safety climate questionnaires and various factors and sub-components were proposed for identifying and measuring safety culture (Zohar, 1980; Reason, 1997; Guldenmund, 2000 and 2007; Flin et al., 2000; Silva et al., 2004; Raja Prasadi and Reghunath, 2010; Fugas et al., 2012). It has been criticized that the comparisons are made difficult because of different variables and that safety culture is reduced to simply a combination of administrative procedures and individual attitudes to safety (Pidgeon, 1998) and that considerations of conflict and knowledge management are absent. In addition, there is some doubt of whether it is enough to measure safety culture using only quantitative psychometric methodologies such as questionnaires or surveys (Pidgeon, 1998) as a measurement tool (Cooper, 2000). Some researchers (Reason, 1997; Cooper, 2000; Glendon, 2008; Zohar, 2008; Bentley et al., 2010; Silva et al., 2004) have emphasized the multidimensional nature of organizational safety culture and needs to implement qualitative (observation, case study, interviews) and quantitative methods (safety climate questionnaire) in order to evaluate and measure different aspects of safety culture in the organization. According to Cooper (2000), alternative or supportive measures for capturing and analyzing the psychological aspect of safety culture include focus group interviews and discussion groups and document analysis. The behavioral aspects of safety culture can be evaluated via observations, and from such sources like risk assessment, accidents and near- misses analysis and reporting documentation, standard operating procedures, the number of weekly inspections completed, the number of audits conducted. The situational aspects of safety culture can be examined from organizational policies, operating procedures, management systems, audits and communication flows (Thompson and Luthans, 1990) as well as from risk assessment reflecting working environment via safety audits.

This study adopted a mixed-method approach, using multiple case studies. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study or series of studies. The reason for this approach was chosen because the research questions required a variety of approaches. Mixed methods are especially advantageous when studying OH&S (Creswell, 2003) since they draw on recognized quantitative data (accident and illness rates, risk levels, auditing results) in combination with qualitative concepts (awareness, attitudes and behavior, risk perception). The aim of this type of research is not to replace either qualitative or quantitative techniques, but to maximize the strengths and minimize the weaknesses of both.

## 2.3.1. Case studies

The case studies were intended to promote better understanding of the rationale of current safety culture in Estonian manufacturing SMEs, the development of needs, obstacles, and the changes that have occurred in the field of OH&S, particularly after Estonia became a member of the EU, as well as to provide

deeper knowledge about senior managers' and employees' perceptions and their commitment to safety, which may influence the overall safety performance in the enterprises. In addition, the case studies were chosen for illustration, exploration and better understanding of safety knowledge and SMSs in Estonian manufacturing SMEs. An inductive approach was applied in case studies. This research approach is based on the selection of case organizations, which are to a certain extent similar to each other. Among case organizations, there are significant differences, such as branches of industry, working environment. These differences potentially have an impact on the results. There are some difficulties in cross-case analysis due to the complex nature of safety culture and research methods, which require extensive and long-term involvement of the researcher to comprehend and understand safety culture. The analytical method adopted in the qualitative case studies was thematic analysis, which comprises describing, classifying and combining the data. The number of cases is debated in the literature with no ideal number stated. However, Miles and Huberman (1994) suggest that the number of investigated cases should not exceed 15 and Eisenhardt (1989) argued that a number between four and ten is sufficient. Eight case studies were conducted and data were gathered from eight SMEs (See Appendix 10) from four branches of industry: the metal industry (3), the textile industry (2), manufacture of devices and the plastic processing industry (2), and the printing industry (1). All the investigated companies were assessed as SMEs - classified in Estonia according to the common classification in Europe (Petts, 1998): small-sized with 10-49 employees and medium-sized with 50-249 employees. The enterprises were chosen based on the most relevant industrial branches in Estonia and were located in different parts of Estonia, however the majority of them were in or around the capital and western part of the country where the main production is located. Data were collected during the period April 2009-October 2009.

The data were gathered from on-site observations, risk assessment, audit, health and safety documentation analysis, safety rules and procedures scrutiny as well as safety interviews with senior managers and employees. The author of the thesis (researcher) was granted access to confidential data provided under confidentiality agreements. Special attention was paid to ascertaining positive aspects expected from a prescriptive safety culture (based on Frazier et al., 2013; Meliá et al., 2012), such as: existence of a safety policy emphasizing safety values and actions in an organization and shared between all employees; well-defined safety procedures and guidelines for all the operations integrated in work procedures; safety resources and investment; specific safety training and supervision; accidents and near-misses investigation; active employees' involvement in OH&S activities and health promotion. Company safety response refers to the state and process of safety and detailed working environment and conditions in the investigated SMEs were analyzed and presented in the articles included in the thesis.

### 2.3.2. Qualitative interviews

According to Bryman (2004), Fellows and Liu (2003), an interview can supplement data gathered by observation and help to uncover the meaning behind the artefact as well as identify the root structure of underlying values and beliefs of safety culture.

Eight semi-structured face-to-face interviews with senior managers in charge of production operations, quality sections of their companies and eight semi-structured interviews with safety managers were conducted. The study focused specifically on the perceptions of senior managers, exploring their attitudes, beliefs, knowledge in OH&S, their commitment to safety, cooperation with OH&S professionals. The objective was to build up a picture that would take into account not only how safety management is organized, implemented and maintained, but also how safety goals and practices are realized practically as an organizational value, how managers valued it, and how they viewed their role in the improvement of safety culture. The interviews were conducted in Estonian and Russian languages. Each interview with a manager lasted for two hours on average and was recorded. All individual interviews with managers at enterprises were completed before the workers' group interviews occurred. Interview thematic plan is presented in Appendix 9. Data for this exploratory study were gathered from eight focus group interviews with 22 industrial workers (13 males and 9 females). A simple random sample was selected from workers employed at the SMEs. According to Alasuutari (1995), in a group situation (group interviews) the culture of the community is actually presented in the sense that when people speak to each other, members of a cultural group can use common language and understandings to convey their collective views and identity. The objective was to gather information about workers' attitudes and perceptions of OH&S, shared visions and values, safety practices, knowledge, and their involvement in safety management. Each focus group session lasted for 45 min on average and was recorded. Interviews were then fully transcribed and analyzed. Every effort was made to protect the privacy, confidentiality, and anonymity of individuals and organizations participating in this study. Results from qualitative study are analyzed and presented in *Articles II, III, V, VII*; Järvis and Tint (2009).

### 2.3.3. Questionnaires

According to Kerlinger (1986), questionnaire design is important as an item that helps to structure an investigation by providing a series of research questions, which like a 'communication instrument', allow obtaining opinions from respondents. The present study questionnaires are derived from previous relevant literature and most of the topics in the questionnaires are derivative or adapted from previous studies (Alavi and Liendner, 1999; Grote and Künzler, 2000; Schein, 1996; Hofstede, 1994; Reich, 2007; Zohar, 1980; Fernández-

Muñiz et al., 2007; Cooper, 1999; Cox and Cox, 1991; Cox and Cheyne, 2000; Cox and Flin, 1998; Mearns et al., 2003; Williamson et al., 1997; Reiman and Oedewald, 2004; Wiegmann et al., 2002; Larsson et al., 2008). The original questionnaires were modified in order to suit the thesis objective. Different questionnaires were used in the current study in order to achieve the aim of the thesis – one was used for the longitudinal (comparative) study of OH&S professionals (in 2002 and 2009), two questionnaires (for employers and employees) were used in a national Work Environment questionnaire survey conducted by Statistics Estonia in 2009.

The longitudinal studies allow an understanding of change over time and throw into focus the issues of variability and predictors of such change over time. In addition, the longitudinal approach individually identifies and analyzes specific strengths, areas in need of improvement in the organization, providing useful information to management seeking to improve safety performance and culture (Mearns et al., 2009). Thus, the survey of OH&S professionals was conducted in 2002 (as a part of the Estonian-Finnish Twinning Project in Occupational Health) and in 2009 (Appendix 8). This study was used in particular to capture real experiences of OH&S professionals, to explore their cooperation with employers as well as their potential and actual role in the creation of safety culture in SMEs and as an external source of safety knowledge. The other purpose was to investigate the changes that have occurred in the field of OH&S, particularly after Estonia's accession to the EU. Statistical analysis involves descriptive statistics and the results are presented in *Articles II and IV*.

A national Work Environment questionnaire survey was conducted by Statistics Estonia in 2009. The objective was to gather information about psychological aspects of safety culture – how employers and employees feel, which attitudes they have and how they are valuing working environment, and environmental issues – what an organization has and does in the field of OH&S. Two questionnaires measuring safety attitudes, perceptions, values, conflicts and relationships, information dissemination, job satisfaction, responsibility and commitment, risk awareness, working conditions and safety measures were administered anonymously to employees and employers from SMEs from different branches of industry. A special feature of the survey is that it is the first linked data set of both employees and employers in SMEs exploring inter alia issues of employees' involvement, representation, responsibility for workplace safety and health, employers' commitment to safety; importance and relevance of the safety requirements and procedures, training and information; how safety is valued and appreciated throughout investigated organization. The survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. Results from the analysis of the data are presented in *Articles V-VII*.

### 2.3.4. Supplementary methods

*On-site observations*
On-site observations are an important part of the methodology (Mengolini and Debarberis, 2007). Observation is an element in the control process situated before the judgement element. Its aim is to monitor, capture and analyze if the transformation and the output of the transformation comply with the organizational values and norms. Observations reveal data about the attitudes, tangible (e.g. safety policies, rituals, stories) and behavioral (e.g. safety norms in action, the prescribed and proscribed safety behaviors at work, in safety meetings and discussions) features of a safety culture. Observations focus on the real aspects of a safety culture, for instance: "*what safety reports are people asked to complete?*", "*how do people talk to each other about safety concerns?*" In combination with semi-structured and focus group interviews they can provide an important base for inferring the basic assumptions of the organization and its (safety) culture. The author performed on-site observations in the form of walk around in the investigated enterprises, visits to working stations and observations of manufacturing processes as well as of work practices. Although the author had field notes on enterprise tours and followed the recommendations suggested by Fellows and Liu (2003), there is an intention to better plan and structure observations in the future in order to fully integrate on-site obserations into the process of the investigation of behavioral and organizational aspects of safety culture, and real safety at the enterprises.

*Written documents*
The current study implemented safety document analysis, such as safety strategy and policy, plan and instructions, risk assessment, safety rules and procedures; audits and inspections, safety meetings, safety committees, safety records, including incidents and accident investigations, training and meeting records were also carefully analyzed in order to complement and verify the data collected during the interviews. The National Labour Inspectorate's assessment reports and strategies for inspection were analyzed (*See Article I*).

*Safety audit*
Kuusisto (2000, p 13) defined audit as "a systematic and independent examination to verify conformance with established guidelines and standards and to examine whether these arrangements are implemented effectively and are suitable to achieve objectives". Several methods or tools have been developed for supporting safety auditing. In the current study the modified Diekemper & Spartz (D&S) method (Kuusisto, 2000) was used to determine safety level in the six SMEs. The current method has criteria for the assessment, as well as a scoring system which produces a numerical estimation of the safety activity level within the organization. The modified D&S method addresses 30 activities, which are categorized into the following activity areas: A - organization and

administration; B – industrial hazard control; C – fire control and industrial hygiene; D – supervisory participation, communication, motivation, and E – accident and near-accident investigation and reporting procedures (*See Article II;* Kempinen and Tint, 2006). This method was selected based on the research aim and because it includes evaluation criteria for such elements as motivation, communication, training activities and leadership. In addition, the results method is easy to use and it addresses all the key areas of industrial SMs. Heinrich et al. (1980) described the audit method as an excellent device for measuring OH&S activities in the organization. However, the research evaluates the method as helpful during the safety audit process and can be used as one of the possible tools to evaluate the company's SMSs for SMEs, but the method does not ensure reliable and valid audit results. The D&S method is rough and it does not help the researcher/auditor to assess the individual safety activities thoroughly (e.g. to measure both the quality and quantity of safety activities and to determine how well occupational hazards are controlled). For example, the requirements for control of industrial hazards, fire hazards and industrial hygiene should be tighter than they are presented in the method and more attention should be paid to such hazards as psychological and physiological hazards. In addition, the determination criteria are fixed, which may lead to a situation where there is no space for improvement for the organization since all requirements seem to be fulfilled.

*Risk Assessment*

Safety risk management is one of the essential factors of SMSs in the organization, which includes risk assessment (identification of hazards, estimation of the risk from each hazard and evaluation of the risk), control of safety measures in order to comply with legal requirements. Risk assessment is a procedure where the severity of the identified occupational hazards is evaluated. According to Makin and Winder (2008), risk assessment could be an effective 'safe place strategies'. In order to evaluate the real safety situation in the investigated SMEs and to explore how safety is valued and practically realized in the investigated enterprises, the risk assessment was conducted, using a flexible risk assessment method (Reinhold et al., 2006). Working conditions were evaluated by assessment and measurements of occupational hazards, measured with the analysis of risks derived from them by the flexible risk assessment tool (*Articles I-III*).

*Media analysis*

In order to investigate media and public attention to the OH&S and, particular safety culture in Estonia, a media review was performed based on newsletters and journals available for the period of January 2009 - January 2013. A search was conducted via the Database of Estonian Articles Index Scriptorum Estoniae, which contains articles from newspapers, magazines and journals, serial publications and anthologies and collections from the 1990s on, allowing the

full-text to be accessed in free digital archives and Web publications. Key words were searched, which were related to the aim of the research. Further, only the content of those articles (in Estonian, Russian, English and German languages) related to health and safety was analyzed (*See Article V*).

*Company homepage analysis*

Safety climate is one of the organizational components of culture that is connected directly to the mission, strategy, and organizational practices. Therefore, in order to examine how organizational vision, strategy, mission and values reflect and express commitment to safety and safety culture, the company homepages were analyzed. At the beginning, eight company homepages of eight SMEs included in the study were investigated. Further, twenty randomly chosen manufacturing SMEs as well as twenty five company homepages of industrial SMEs (of the most competitive fifty enterprises from the Estonian Companies' Competitiveness Ranking 2012) were also analyzed (*See Article V*).

## 2.4. Data analysis

*Qualitative study*

Qualitative data were used in six of the seven publications and gathered in three separate data sets. *Article II* employs the first qualitative set of data collected from six manufacturing SMEs by interviewing employers. *Article IV* employs the second qualitative set of data gathered from seven SMEs by interviewing employers and on-site observations. *Articles V and VII* employ the third set of data gathered from eight SMEs through interviews (employers, safety managers and employees) and case studies conducted in the spring-autumn 2009. In total, 24 interviews were conducted in the investigated manufacturing SMEs from four industries. The interviews followed a thematic guide (Appendix 9). Data from semi-structured interviews with senior managers and safety managers as well as from focus group interviews with employees were carefully transcribed, the researcher went through each case separately making notes and getting to know each one before conducting the analysis.

Triangulation helps in overcoming bias that comes from a single method. In this data set, triangulation covered the source (Voss et al., 2002), using interviews as primary data and documentation, observations, risk assessment and audit as secondary data, which helps in checking the consistency of different data sources with the same method. In addition, the fact that two senior managers were interviewed by the researcher per enterprise also helps to determine the level of consistency in the interviews. The study used researcher triangulation as suggested by Olander (2011), where all co-authors read the analyzed data which were then discussed.

*The quantitative study*

Statistical analysis involves descriptive statistics and exploratory factor analysis. Descriptive statistics was used in *Articles I-V*. Factor analysis was applied to data acquired from a national Work Environment questionnaire survey conducted by Statistics Estonia in 2009. The survey comprises a sample of 463 employers and 1757 employees. The data for *Articles VI-VII* were analyzed using the Statistical Package for Social Science (SPSS 17.0) software. Exploratory Factor Analysis was utilized to examine the dimensions of safety culture as measured by the safety culture survey. This method was used to uncover the latent structure (dimensions) of a set of variables by measuring correlation of the different factors and thus weed out the ones that are not related to each other. Additionally, exploratory factor analysis was requisite for examining the appropriateness of the factor structure. Statistical t-test of the mean was conducted to check the entire population's likely response to the issues raised in the questionnaire, based on the sample's ratings. The Principal Components Analysis with Varimax Rotation was conducted (in SPSS 17.0) on 35 items (for employees) and 30 items (for employers) and resulted in sixteen factors (for employees) and ten factors (for employers) with an eigenvalue greater than one (Tables 5 in *Articles VI-VII*).

## 3.    RESULTS:  The role of knowledge management in safety management systems

In order to fulfil the aim of the doctoral thesis, to enhance the understanding of the role and importance of KM to SMs, the study analyzed different aspects related to KM, safety culture and the key features of SMSs. All the selected seven scientific articles explain the basic framework and provide a general overview of safety knowledge management at the enterprise and state levels from safety culture perspective and answer the main research question: *what characterizes safety culture and how it is associated with safety KM within the Estonian manufacturing SMEs*, thus fulfil the aim of the thesis.

More specifically, each publication covers and elaborates a range of aspects of SMSs in manufacturing SMEs with a special focus on safety knowledge dissemination and transfer in safety culture context. Table 1 summarizes the objective, the methodology used and the main contribution of each article. Below the author will introduce them briefly and will identify the specific importance of each article and their interrelation to the cumulative development of the overarching research question which is to be addressed concerning concepts of SMSs and safety culture within the manufacturing SMEs, possible factors that enable and promote management of safety knowledge. The order of the articles is as follows: *Article I* starts with more generic issues of the

supervision of the working environment and the role of a risk observatory in information dissemination and safety knowledge sharing and transfer as well as explores the main changes in the OH&S in Estonia. *Article II* then examines working conditions and possible occupational hazards in the selected enterprises and analyzes SMSs. This paper reports employees', employers' and OH&S professionals' awareness about OH&S and the changes that occurred in the field of OH&S in the context of Estonian accession to the EU. This leads to the further investigation, in particular, of the real safety situation and its management in the context of SMEs (*Article III*). It is studied further in *Articles IV and V* in view of importance of positive safety culture and management of existing safety knowledge in these enterprises. Moreover, as the lack of theoretical and practical work on KM in the field of OH&S is one of the main parts in SMSs, *Articles IV and VI* describe an innovative conceptual model for the improvement of safety culture consisting of KM dimensions developed by the author that incorporates both tacit and explicit safety knowledge. The model of safety culture proposed by the author that served as a basis for the development of a questionnaire, which when used as part of safety management audits, can support an assessment of safety culture. It has been found valuable for SMEs. Therefore, *Articles VI and VII* proceed to explore the relationships between organizational, psychological and behavioral aspects of safety culture using the proposed assessment tool.

## 3.1 Risk Observatory- A tool for improving safety and health at the workplace

*Overall objective*
The study (*Article I*) aimed to assess the working environment, the employers' possibilities and willingness to conduct risk assessment, ways to manage risks and the steps towards progressive improvement in the field of OH&S. The article explores the main changes and challenges in the Estonian OH&S system in the context of Estonian accession to the EU based on the changes of NLI priorities and strategy for supervision, changes in the working environment (data form risk assessment in two firms); employees' opinion in comparison with data from Baltic Working Environment and Labour (BWEL) survey (Woolfson, et al., 2008). This article (see Appendix I) investigates the role of the NLI in the risk observatory as a main key authority in data collection, information and knowledge dissemination in OH&S. The sub-research question that this paper aims to answer is (2) *what characterizes SMSs within the Estonian manufacturing SMEs and what kind of changes in the field of OH&S occurred in the context of Estonian accession to the EU.*

*Results and main contribution*
The paper suggests that NLI should play a vital role in safety knowledge sharing and transfer at the state and enterprise level. The findings revealed that the

Estonian working environment has changed considerably during the last ten years and is continuing to evolve as a result of the following trends much in line with broader European trends identified in the key EU strategy documents on OH&S.

Even though rapid improvement has been made in the field of OH&S in Estonia in recent years, there are still challenges ahead. The effectiveness of the present OH&S system is undermined by the insufficient coverage of OHS, lack of political will to meet EU OH&S requirements, lack of relevant statistical data and research activities in the field, poor quality of risk assessment and the continuing absence of an insurance act for occupational accidents and diseases which effectively places the burden of compensation, support and rehabilitation. The article presents several recommendations for the improvement of the OH&S system: to conduct further research in OH&S; to enhance the effectiveness of an OH&S monitoring system to include quantitative as well as qualitative data and to support knowledge-based administrative decisions on legislation, law enforcement, research and setting of priorities, monitoring changes and identifying emerging risks, as well as designing and setting up corrective and better preventive measures. There is also a need for further identification and anticipation of emerging occupational risk and an evaluation of many safety measures that are in place or planned. To achieve positive results, it is necessary to strengthen the national OH&S system in Estonia as well as the public awareness through tripartite collaboration. This includes legal provisions, enforcement, compliance and labour inspection capacity and capability, KM, information exchange, research and support services. Finally, the suppression of good practice in OH&S requires that representatives of the workforce be empowered in the process of OHSMs at the enterprise and workplace level.

## 3.2 The formation of a good safety culture at the enterprise

*Overall objective*
The issues identified *in Article I* are further explored in *Article II* (see Appendix II) which links SMSs and safety culture. The article addresses two sub-research questions: (1) *how safety is valued, appreciated and practically realized in the investigated enterprises and what characterizes safety culture within the Estonian SMEs*; (2) *what characterizes SMSs within the Estonian manufacturing SMEs and what kind of changes in the field of OH&S occurred in the context of Estonian accession to the EU*. The article examines working conditions in the selected enterprises and safety auditing of SMSs. This paper reports employees' and employers' awareness about occupational hazards and safety measures, as well as the results of a national survey of OH&S practices and development needs in Estonia.

*Results and main contribution*
The article assesses the possible economic losses connected with poor safety management in Estonia and describes the system of occupational disability and occupational accident insurance. The practical part of the investigation consists of data analysis from six SMEs, where risk assessment and audit of SMSs were conducted using the modified Diekemper & Spartz method (Kuusisto, 2000). The results of auditing of SMSs indicate that the main problems in the investigated enterprises were as follows: lack of safety education and training of employers and employees, particularly for new employees; the absence of the written safety policy and safety plan as the framework for health and safety activities in the enterprises; occupational accident investigation, statistics and reporting procedures, especially near-misses, were found weak in all enterprises and there was a lack of employees' involvement in health and safety activities. Majority of the employees (who handled chemicals at their workplace) had received no specific training on chemical safety. The information about chemical hazards was not available at workplaces in two processing enterprises (metal and mechanical). Results from semi-structured interviews with senior managers revealed their low awareness and commitment to safety. The level of safety performance varied in different investigated enterprises. All managers considered the risk to their employees' health sufficiently low. However, majority of the interviewed managers had a certain plan of activities to improve working conditions, but not documented. Safety policy and plan that set the framework for OH&S activities in enterprises were not available in written form in seven of the eight enterprises.

An interesting finding was also that none of the interviewed senior managers had tried to evaluate the economic losses that had been caused by employees' sicknesses and/or occupational accidents as well as to evaluate effectiveness of the OH&S interventions.

The study contributes to increased understanding of the changes occurring in the field of OH&S in the context of Estonian accession to the EU, how safety is valued and practically realized in the investigated enterprises. The authors proposed a complex approach to the management of OH&S issues and possible tools – simple computer-based applications for the identification of occupational hazards.

## 3.3 Risk assessment and measurement of hazards in Estonian enterprises

*Overall objective*
*Article III* (see Appendix III) addresses the sub-research question: (2) *what characterizes SMSs within the Estonian manufacturing SMEs and what kind of changes in the field of OH&S occurred in the context of Estonian accession to the EU.* The objective of the article is to explore real safety in SMEs by examining the working conditions and current practices and the mechanism of

management safety in the SMEs. The article focuses on successful risk assessment procedures in SMEs as well as on safety knowledge sharing and transfer at the enterprise level.

*Results and main contribution*
The article provides knowledge on the real safety (working conditions) in the manufacturing SMEs and measures to control risks. According to the results from the study, the working conditions varied between investigated enterprises. The article presents the results of measurements of occupational hazards (indoor climate, lightening, noise, dust and chemical) and risk assessment conducted in 18 SMEs from six industries, using a flexible risk assessment method (Reinhold et al., 2006). The results from the study reveal that the main identified hazards with a high risk level were noise, dust and indoor air humidity.

   The authors emphasize the importance of risk assessment as an inevitable and practical procedure where the severity of the identified hazards is evaluated in order to prevent occupational accidents at the enterprises. The article presents an analysis of safety knowledge sharing and transfer at the enterprise level and suggests the key elements of the SMs in order to improve the working environment: risk assessment, cooperation between employers and OH&S professionals (as a source for external safety knowledge), employees' involvement and appropriate safety training for the employers and employees.

## 3.4 Innovations at workplace: an evidence based model for safety management

*Overall objective*
The objective of the article is to explore the link of OH&S and KM and to clarify the concept of safety culture. *Article IV* (see Appendix IV) addresses two sub-research questions: (2) *what characterizes SMSs within the Estonian manufacturing SMEs and what kind of changes in the field of OH&S occurred in the context of Estonian accession to the EU* and (3) *how safety management systems reflect one of the major factors – safety knowledge within the Estonian manufacturing SMEs*. In addition, the article evaluates the OH&S professionals' attitudes, their potential and actual role in the creation of safety culture at the enterprises and proposes a model for the improvement of safety culture.

*Results and main contribution*
The article presents the results of exploratory case study research in order to assess the safety culture elements in Estonian manufacturing SMEs. In addition, the study describes the senior manager's attitudes and knowledge level and suggests and shows the innovative possibilities for the improvement of safety culture at the Estonian SMEs through complex approach to safety and health, which includes a KM system. Qualitative investigation of the safety culture, which allows gaining insight into various public policy factors (external factors), might influence safety knowledge creation and its transfer, development of

communities of practice (CoP). The results from the comparative questionnaire OH&S professionals' survey (2002 and 2009) increase understanding of the changes that occur in the field of OH&S. It is interesting that according to the results from the study of 2009, the main priorities and major problems in the current OH&S in Estonia were exactly the same as reported by the OH&S professionals in 2002 (Kempinen and Sarap, 2002). The study suggests that there is a need for discussion and improvement of collaboration between employers and OH&S professionals in order to strengthen KM and the infrastructure as well as safety culture at the Estonian enterprises. Competence and expertise in health and safety topics is the foundation for the added value of OH&S professionals to the safety and health of working population. The authors' proposal was that OH&S professionals be looked at in a new way as a fresh resource of knowledge and competence with defined capabilities, and that their position description be developmental that emphasizes these capabilities at the state as well as organizational levels.

This article contributes to theory in two ways. First, it provides conceptual clarification on the role of KM in the field of OH&S and, as the constituents of safety culture. Second, the article commences with a discussion on an innovative conceptual model for the improvement of safety culture consisting of knowledge management dimensions that incorporate both tacit and explicit safety knowledge. The authors emphasize the importance of CoP as a source of safety culture and as the 'one important focus' of learning, transmitting practical safety knowledge as well as sharing values among members of the CoP, through which an organization can grow, learn and develop new intellectual capital.

## 3.5 Formal safety versus real safety: quantitative and qualitative approaches to safety culture – evidence from Estonia

*Overall objective*
*Article V* (see Appendix V) addresses several sub-research questions: (1) *how safety is valued, appreciated and practically realized in the investigated enterprises and what characterizes safety culture within the Estonian SMEs* and (3) *how safety management systems reflect one of the major factors – safety knowledge within the Estonian manufacturing SME*. The intention of this article was to bring an understanding to the concept of safety culture and real safety behavior in investigated companies; to examine differences between formal and real safety as well as to discuss alternative possible approaches to safety culture - through managing the safety social capital inherent in Estonian SMEs.

*Results and main contribution*
Analysis of the safety culture questionnaires shows many SMEs with an outstanding safety culture and positive safety attitudes. Safety training, safety work procedures, relevant information provision, communication and supervision – all important aspects of the organizational life are viewed from the

OH&S perspective and were positive, which Meliá et al. (2012) called 'prescriptive safety culture'. The study identifies the main shortages in risk assessment and efficiency of safety measures as well as some important safety flaws in all investigated SMEs. Employees' involvement in different activities in health and safety as well as the possibility to learn in the organization were limited and weak. In addition, the study showed a lack of commitment, cooperation and social capital in SMEs as well as that OH&S is not a company's core issue and safety is not considered as a vital factor for promotion/advocacy in the companies' homepages as one part of the company identity. This study contributes important empirical evidence on how SMEs address OH&S and what the major challenges in SMSs are.

The article also contributes in several ways to the theory of safety culture and methodology. First, the article analyzes safety social capital and workplace conflicts as a part of culture, suggests focusing on CoP as a source of safety culture. Second, the study contributes to the methodology for evaluation of safety culture by providing knowledge on the essential aspects in the process of evaluation of safety culture, like organizational, human and social perspectives in safety. The study revealed that a quantitative approach using a reliable and valid tested questionnaire can provide an overview of the safety climate (employees' perception and attitudes) and an overall safety organizational picture. However, safety documentation and questionnaires tend to reflect only 'formal' procedures in the organization. It is not enough in order to understand the 'real' state of the safety, procedures, the shared and active values and beliefs that guide behavior patterns and OH&S activities in the organization. Therefore, integrated approaches should be used, which allow employees and employers to declare and reflect some important safety flaws.

## 3.6 Knowledge Management: a neglected dimension in discourse on safety management and safety culture – evidence from Estonia

*Overall objective*
*Article VI* (see Appendix VI) addresses sub-research question: (4) *which are the enabling and inhibiting factors that will foster the safety knowledge exchange within manufacturing SMEs?* The objective of the article was to propose a model for a positive safety culture with a KM dimension and empirically test this on a sample of 1757 employees from different branches of industry, using the exploratory factor analysis statistical technique.

*Results and main contribution*
The current article explores the possibility to use KM in an OH&S and SMs. The article supplements Cooper's Reciprocal Model of Safety Culture (Cooper, 2000) with KM dimensions, which takes into account the dynamic interrelationships between safety climate, SMs, safety behavior and management of safety knowledge within the organization. In addition, the current article

reports on empirical examination of the relationship between safety climate and safety culture, including the hitherto neglected KM. The results of this study indicate that safety climate has an impact on the three dimensions of safety culture. Factor analysis was applied to the 35 factors stating the effects of positive climate in order to identify the possible underlying patterns among the original variables. After the application of factor analysis, 16 factors were grouped into principal seven components under each main category and the related factors and were later on combined into three: organizational, psychological and behavioral aspects of safety culture. Several specific features of KM, such as safety knowledge dissemination, communication and personal responsibility were found to influence the relationship between safety climate and safety culture.  The article proposed a new model for a positive safety culture with the KM dimension as an effective management tool to assess and promote a viable and sustainable safety culture.

## 3.7 Managers' perceptions of organizational safety: implication for the development of safety culture

*Overall objective*
*Article VII* (see Appendix VII) addresses the sub-research question: (1) *how safety is valued, appreciated and practically realized in the investigated enterprises and what characterizes safety culture within the Estonian SMEs* and (4) *which are the enabling and inhibiting factors that will foster the safety knowledge exchange within manufacturing SMEs*. The objective was to test the proposed model for a positive safety culture with KM dimension, on a sample of 463 Estonian SMEs from different branches of industry, using the statistical technique of the exploratory factor analysis.

*Results and main contribution*
Several specific features of safety and KM, such as management commitment to safety, safety information dissemination, and communication, workers' involvement in safety werefound to influence the relationship between safety climate and safety culture. The article presents the results from eight case studies, which collectively contribute to a comprehensive description and qualitative assessment of the safety culture in manufacturing SMEs. The articles address the organizational context of safety culture, which evaluates such aspects of positive safety culture as follows: '*safety is a clearly recognized value in the organization';* '*senior managers concern and commitment to safety, how it is evident at all levels in the organization. The necessary allocation of resources, including time, equipment, personnel and finance, is being made';* '*roles and responsibilities are clearly defined and understood'; 'safety is integrated into all activities in the organization'; 'safety culture is learning driven in the organization'*. The current article contributes to conceptual clarification on incorporated conflict management as a learning instrument and

shows its possible effect on safety culture and for knowledge exchange. In addition, the study investigates relationships between employers and employees, co-workers, co-worker peer support and personal responsibility for safety, which is sparsely reviewed in the scientific literature (Frazier, et al., 2013; Fernández-Muñiz et al., 2007; Flin et al., 2000; Harvey et al., 2002; Geller, 2001). The article suggests that the established SMSs have to be a fully integrated part of general management system in the organization and the development of 'communities of practice' is an effective way for employees to exchange explicit and tacit safety knowledge in the organization (See Figure 6).
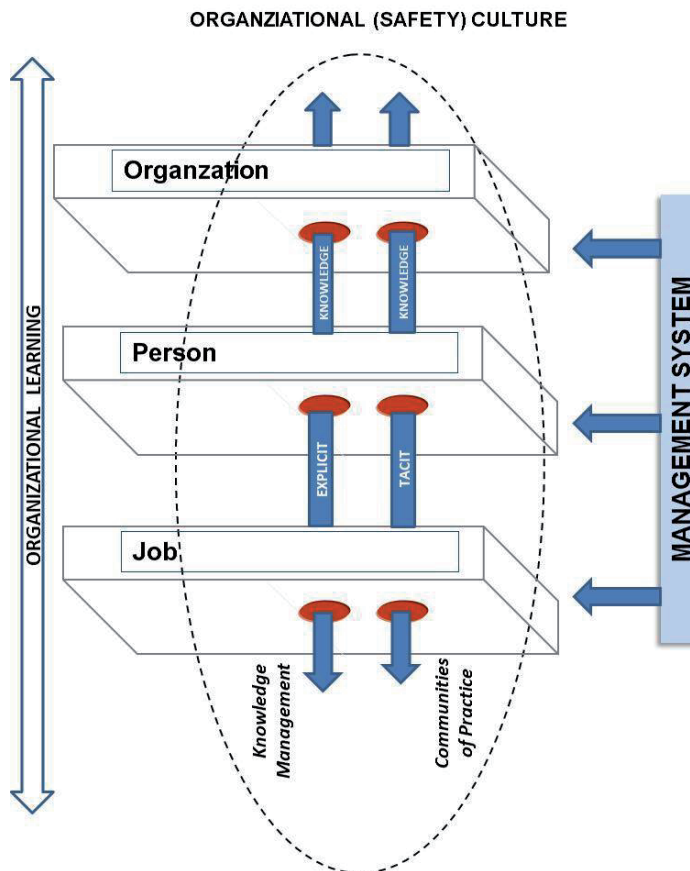


Figure 6. Tacit and explicit knowledge management (Source: compiled by the author)

The article also concludes that in order to codify personal tacit knowledge into explicit and practical knowledge for all employees within the organization, it is essential that the process of safety knowledge management needs to be acknowledged and valued by the management.

## 3.8 Development of a management tool to support the assessment of safety culture

The proposed model provides a theoretical basis for the assessment and development of safety culture as well as the improvement of safety knowledge management in manufacturing SMEs in order to maintain and to develop real safety culture.

### *The Cooper's safety culture model revisited*

The central concern linked to the efforts to conceptualize and maintain safety culture has been to support a diagnosis of the state of SMs in an organization beyond the directly visible characteristics of formal technical and organizational safety programs (Grote and Künzler, 2000). Many researchers (Cooper, 1999; Geller, 1996; Choudhry et al., 2007; Grote and Künzler, 2000; Reason, 1993; Teo and Feng, 2009; Zohar, 1980) have attempted to explain safety culture through models (See *Articles IV, VI*). A major problem with most existing models of safety culture is that they are not integrated into general models of organization and organizational culture. In addition, less attention has been paid to human activities and social relationships shared between members of an organization, their values, behavior patterns (Schein, 1992; Grote and Künzler, 2000), relationships between people and how safety knowledge (especially tacit knowledge) is exchanged, managed and used. Reviews of safety culture surveys identified some common aspects, for instance: importance of management concern and commitment, personal responsibility, employees' involvement in health and safety activities, and the SMSs (Cooper, 1999; Flin et al., 2000; Frazier et al., 2013; Guldenmund, 2000).

There is also limited empirical research to substantiate which company values, safety-related characteristics of a system (job and organizational design, the use of technology etc.), have the most demonstrative impact on safety culture. Despite conceptual and empirical justification, researchers have not consistently included concepts of KM in investigating safety culture issues like knowledge, skilled and motivation are generally included only in the evaluation of psychological aspects of safety culture (Cooper, 2000; Reason, 1997).

In order to fill this gap in the literature, based on previous empirical research and literature review, the current study explores the possibility of using KM in the OHSMs and proposes an innovative conceptual model for the improvement of safety culture consisting of KM dimensions that incorporate both tacit and explicit safety knowledge and understandings based upon CoP. The author emphasizes the importance of CoP as a source of safety culture and as the 'one important focus' of learning, transmitting practical safety knowledge as well as sharing values among members of the CoP, through which an organization can grow, learn and develop new intellectual capital. This study concerns organizational safety culture and the structure or architecture of employees'

attitudes to safety as part of that culture, as well as the ability to learn, which also should mean changes in worker's behavior in order to enhance safety culture.

This model is based on Cooper's (1999) Reciprocal Safety Culture Model, with added Knowledge Management Dimension, which can allow in-depth study of the impact of managing of safety knowledge on the development of safety culture processes (See Figure 7). The model proposed takes into account the dynamic interrelationships between safety climate, SMSs, safety behavior and motivational strategies for safety knowledge exchange within a CoP at the enterprise level. Thus, the author suggests that organizations should pay more attention to how their safety knowledge is managed (how knowledge is created, transferred, exchanged and used by employees) in order to develop a positive safety culture and to change employees' safety behavior. The suggested knowledge elements of the model can also be broken down into exactly the same reciprocal relationship (*Article VI*).
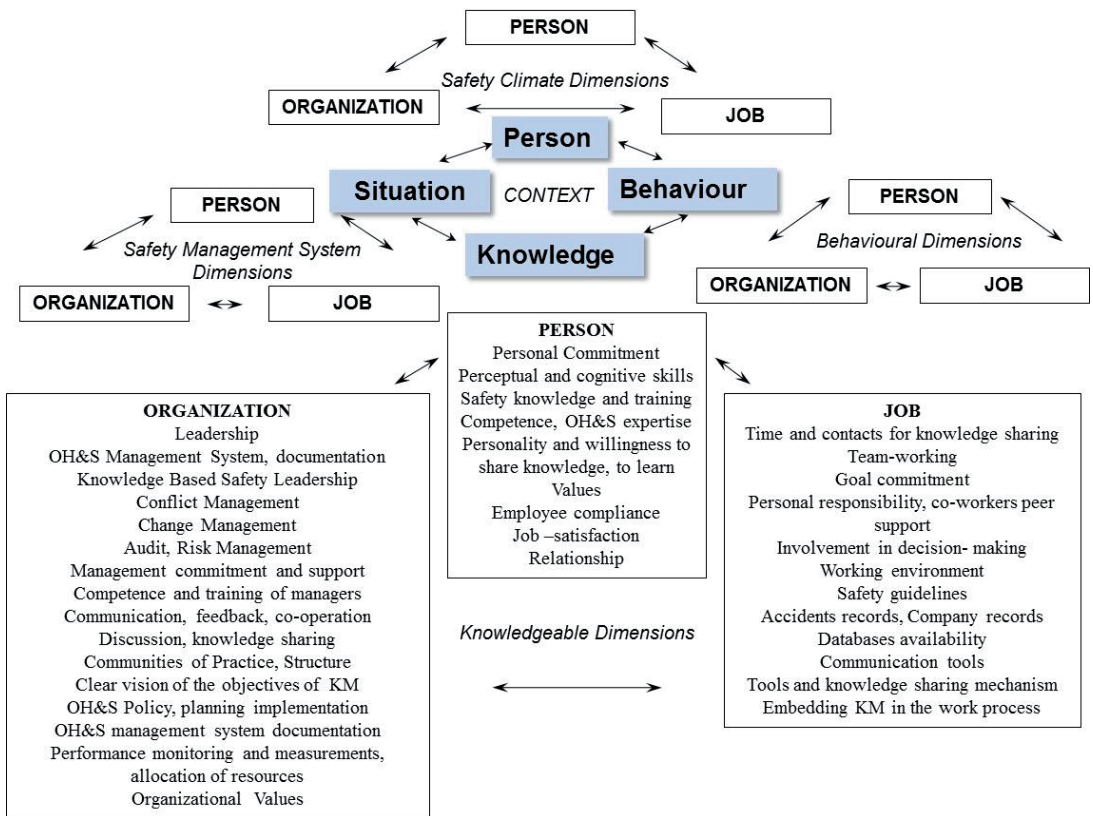


Figure 7. Reciprocal safety culture model (Source: compiled by the author)

In the following, a model of safety culture is briefly presented in which the KM approach was used to better link safety management and safety culture. The thesis gives new insight by presenting a theoretical model of safety culture with

KM dimensions, which served as a basis to develop a questionnaire which when used as part of safety management audits can support the assessment of safety culture. In addition, this model can be seen as an effective management tool for changes and diagnosing the warning signals to issues that need to be improved in order to develop and maintain sustainable safety culture.

According to Cooper's model (1999), the concept of safety culture contains three elements, which are related to people, their behavior and their interaction with the SMs within organization: internal psychological factors (safety climate), external observable factors – organization (SMSs) and job (safety behavior). In addition, all elements of the model can also be broken into exactly the same reciprocal relationships, thereby allowing the multi-faceted nature of the safety culture construct to be systematically evaluated (Cooper, 1999).

The proposed model by the author of the thesis supplements Cooper's Reciprocal Model of Safety Culture with KM dimensions based on the previous research and theory, which was complemented by the information gained from case studies (observation, safety audit, risk assessment) and interviews with senior managers, safety managers and employees. Even though the current research is mainly qualitative and attempts to explain the phenomenon (safety culture) and to make it more understandable, the essence is to create an exploratory model that applies as comprehensively as possible to the data it has been derived from. Safety audits and risk assessment provided information on what operational measures have been taken to integrate safety into the work process. The focus of the questionnaire was to complement that information with perceptions and needs with respect to those measures expressed by the members of the organization and their perception and need with respect to managing safety knowledge.

The questionnaire developed as a part of national questionnaire survey (conducted by Statistics Estonia in 2009). The author participated in this project as an expert during the preparation of the questionnaire. Two questionnaires measuring safety attitudes, perceptions, values, conflicts and relationships, information dissemination, job satisfaction, responsibility and commitment, risk awareness, working conditions and safety measures were administered anonymously to employees and employers from Estonian enterprises. The questionnaires also included additional items not relevant to the present thesis research and were excluded from the analysis. Based on the aim of the thesis, only relevant data were used with the primary focus on the management of safety knowledge in the manufacturing SMEs. The main core constructs of the proposed safety culture model, which were tested in the current study, are described in *Articles IV, VI*. The model questionnaire contains three sets of items related to the organizational ('organization'), psychological ('person') and behavioral ('job') aspects of safety culture with a special focus on KM (See Figure 7). The measurement scale of the study variable is presented in Appendix 11. The measurement scales of the concepts used in this work were constructed following a multiple indicator approach /each concept was measured using

various items or variables). First, an exhaustive review of previous studies on safety management and safety culture, both theoretical and empirical, was made (Fernández-Muñiz et al., 2007; Flin et al., 2000; Frazier, et al., 2013; Guldenmund, 2000; Grote and Künzler, 2000; Williamson et al., 1997; Reiman and Oedewald, 2004; Wiegmann et al., 2002; Zohar, 1980). The original questionnaires were modified in order to suit the thesis objective. Here are some important sources of each scale used: SMSs (Grote and Künzler, 2000; Guldenmund, 2000; Hale et al., 1997; Bently and Haslam, 2001; Cox and Cheyne, 2000; Fernández-Muñiz et al., 2007; Lee and Harrison, 2000); employees' involvement (Cooper, 2000; Cox and Cox, 1991; Cox and Cheyne, 2000, Mearns et al., 2003; Fernández-Muñiz et al., 2007); managers' commitment (Cox and Cheyne, 2000; Grote and Künzler, 2000; Wu and Lee, 2003; Fernández-Muñiz et al., 2007) social capital and knowledge sharing (Chang et al., 2011; Ajmal, 2009; Olander, 2011); safety behavior (Larsson et al., 2008).This process provided a pool of items to measure some of the concepts considered in the study. As seen in Figure 8, the research steps included literature review of existing models and possible dimensions of safety culture; interviews, questionnaires and various methods of analysis, as described below.

The questionnaire finally consisted of a total of 50 items for employers and 55 items for employees. The final composition for the main scales is presented in Appendix 11. *Articles VI-VII* report on an empirical examination of the relationship between safety climate and safety culture through a KM dimension with a special focus on the management of safety knowledge. The results of this study indicate that safety climate has impact on the three dimensions of safety culture, namely psychological, behavioral and organizational aspects of safety culture. Several specific features of knowledge management, such as communication, personal competence and responsibility, werefound to influence the relationship between safety climate and safety culture.
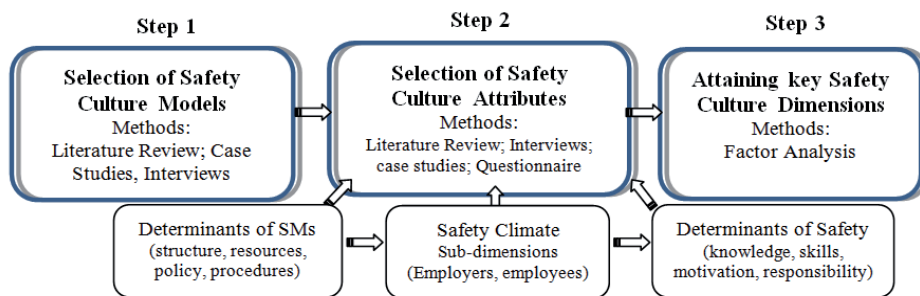


Figure 8. Analytical steps (Source: compiled by the author)

Thus, an effective assessment tool for the evaluation of safety culture could be proposed based on the results of this study. No validated set of indicators exists yet. However, the proposed safety culture assessment tool with its recent enhancements should be adopted as one of the management tools for assessment and promoting a viable and sustainable safety culture. The current model

provides advance warning of the safety culture what should be changed and allows in-depth studying the management of safety knowledge and, thus, can assist in the on-going analysis and implementation of a positive safety culture. Silverman (1998) claims that the validity of the results relates to the extent that research allows generalized observations to be made. The model has been created following these principles. According to Silverman (1998), in terms of reliability, audio-recordings and their transcription using standard conventions meet the demand of interview procedure as well as that of documenting the data collection procedures. The further development of the model is needed in order to test the usability of the integrated approach to SMSs and to validate it, which is discussed in section 4.4

The author emphasizes that the vital part of the implementation of the proposed model is the proactive integration of safety into organizational structure and processes as well as employers' commitment, employees' involvement: organizational SMSs need to demonstrate a full understanding of an organisation's hazard profile by the application and co-ordination of appropriate prevention and control strategies as well as employers' and employees' commitment to safety and effective employees' involvement in health and safety activities.


# 4. CONCLUSION

This chapter summarizes the theoretical and practical contributions of the study, discusses the limitations, possible implications and gives some suggestions for further research.

Knowledge is considered a significant constituent for organizational performance (Chua and Lam, 2005) and now also is the central resource to achieve the goal of OHSMs (Sherehiy and Karwowski, 2006). There is a critical and essential link between safety culture and the SMSs through shared values and beliefs that guide behavior patterns and health and safety activities in the organization. A strong safety culture is generally considered as a vital condition to well-functioning SMSs (Bently and Tappin, 2010; Fernández-Muñiz et al., 2009).

This dissertation investigates safety KM in the enterprise and state levels from a safety culture perspective. More specifically, each publication covers and elaborates a range of aspects of SMSs in manufacturing SMEs with a special focus on safety knowledge dissemination and transfer in a safety culture context.

The findings of the study suggest that a need for knowledge-based change in the field of OH&S in Estonia is urgent, which could be also one of the effective and most powerful strategies for organizational development. First, to achieve positive results, it is necessary to strengthen the national OH&S system in Estonia as well as the public awareness through tripartite collaboration. This includes legal provisions, enforcement, compliance and labour inspection

capacity and capability, health and safety knowledge management at the state level, information exchange, research and support services. In addition, the development of good practice in the field of OH&S requires that representatives of the workforce be empowered in the process of SMSs at enterprise and workplace level. Based on the study results, the author suggests that organizations should pay more attention to their safety KM system in order to develop effective SMSs as well as a positive safety culture in SMEs. In addition, the essential aspects of the positive safety culture are the managers' commitment, the employees' involvement and the effectiveness of the SMSs (Fernández-Muñiz, 2007). The established SMSs have to be a fully integrated part of their general management system in the organization that addresses occupational accident prevention; preparedness and response (See Figure 8). The SMSs should include the organizational structure, practices, procedures and resources for implementing the safety policy.

At the enterprise level, there is also a need for effective KM training – a support system in order to provide an organization with strategic advantages and help to develop a learning environment which can help create and maintain skills in safety, and therefore create the positive safety culture. Based on survey evidence, the author developed and proposed a possible management tool for diagnosing safety which can be used as part of SMS audits. In addition, the author emphasizes that two main factors in the process of managing of safety knowledge and organizational learning are essential for strengthening and enhancement of SMSs: the development of a CoP (gives a possibility for learning and transmitting practical safety knowledge and, thus, for collective learning) and a supportive and harmonized safety culture where knowledge-sharing is valued by everyone in the organization. In order to codify personal tacit knowledge into explicit and practical knowledge for all employees within the organization, it is essential that the process of the safety knowledge management be acknowledged and valued by the management. The CoP can be established and moderated by organizational climate (supportive and open reporting culture that is blame-free) and organizational structure (less formalized, less centralized and more integrated) as well as managed.

## 4.1. Thesis contribution

This section summarizes the contribution to knowledge made by the thesis. The present dissertation is innovative in several respects. The original contribution of the dissertation in both theoretical and practical terms lies in the following:

*Theoretical contributions*
    The main contribution of the study is the developed and empirically tested innovative conceptual Model of Safety Culture with Knowledge Management Dimensions that incorporates both tacit and explicit safety knowledge and

understanding based upon "communities of practice." The theoretical model of safety culture with knowledge management dimensions, which served as the basis for the development of a questionnaire which when used as part of safety management audits, can support an assessment of safety culture. In addition, this model can be seen as an effective management tool for changes and diagnosing the warning signals with regard to issues that need to be improved in order to develop and maintain sustainable safety culture, allowing in-depth study of the management of safety knowledge and assisting in the on-going analysis and implementation of a positive safety culture. In addition, the model proposed takes into account the dynamic interrelationships between safety climate, safety management systems, safety behavior and motivational strategies to create, transfer and utilize safety knowledge within a community of practice at the enterprise level.

The dissertation contributes important empirical evidence on how SMEs address OH&Ss and explores the main challenges in this field. The dissertation provides an assessment of differences between 'formal' safety and 'real' safety in Estonian SMEs from different industries, indicating some important safety flaws and drawing attention to contextual variables in the development of safety management systems and the practical means for improving the safety cultures. In addition, the present dissertation provides proposals on managerial intervention on how to improve management of safety knowledge and overall safety within enterprises, through managing the store of safety social capital inherent in an organization, implementing organizational structures which allow for managers and employees to interact and cooperate, and learning from safety practice and experience. The author confirms through new empirical findings the importance of the notion of a Community of Practice (CoP), as a source of safety culture and as the 'one important focus' of (collective) learning and transmitting practical safety knowledge.

The present dissertation sheds new light onto the existing understanding of the current OH&S system and on the changes occurring in this field in the context of Estonian accession to the European Union. This study of a national-led intervention in OH&S policy evaluation and implementation illustrates the limitations and possibilities of disseminating national level strategic understandings to enterprise levels. The author proposes several recommendations for the improvement of the national OH&S system.

The dissertation provides conceptual clarification on the role of KM in the field of OH&S and, in particular, for safety culture, as well as contributes to theory by proposing a possible approach to improve the safety culture – through managing the safety social capital inherent in an organization. This dissertation is the first to apply intellectual capital principles to the field of OH&S in Estonia, with a special focus on the KM system as an umbrella for capturing a range of organizational concerns towards health and safety.

Another important contribution of the dissertation is in providing conceptual clarification on incorporated conflict management as a learning instrument and

its possible effect on safety culture and for knowledge exchange. In addition, the study investigates relationships between employers and employees, co-workers, co-worker peer support and personal responsibility for safety, which has been sparsely reviewed in the scientific literature (Frazier, et al., 2013; Fernández-Muñiz et al., 2007; Flin et al., 2000; Harvey etr al., 2002; Geller, 2001).

The dissertation contributes to theory by opening new research perspectives in the field of SMSs and safety research, especially on the management of psychosocial risk, as well as for health and safety promotion within the enterprises, by focusing on the incorporation of health and safety knowledge as related to a set of core values in safety culture, resulting in a framework for developing a health and safety culture including social capital.

*Methodological contributions*
The present dissertation has made two major contributions to the existing methodology. First, the dissertation sheds new light onto the existing usability and applicability of the Diekemper & Spartz (Kuusisto, 2000) method for supporting safety auditing.

The second methodological contribution, in terms of safety culture research, is in the focus on the often-neglected area of the implementation of organizational safety culture. Moreover, this was a multiple case study design allowing cross-case comparisons, providing perhaps more comprehensive understanding of the phenomenon studied than the single case studies or safety climate questionnaires that have been more common in this research area. The thesis contributes to the methodology of the evaluation of the safety culture by applying quantitative approaches ('perceptual measurement-individual attribute approach', which capture organizational safety climate through perceptions of individual attributes) and a qualitative approach (case study, interviews, observations, audit and risk assessment, document analysis), which allows the capture and deeper analysis of organizational, behavioral and psychological aspects of safety culture.

## 4.2. Implications

The practical concern of this thesis is to improve OH&S in Estonia with a special focus on SMEs. The thesis identifies commonalities in the need to improve the contribution of safety knowledge to safety management processes and practices in a selected sample of Estonian SMEs in different economic sectors, suggesting that while there may be some variations between sectors in the application of safety knowledge, further economic benefits and improvements in employee well-being could be secured across all sectors reviewed by creating the appropriate conditions in which to embed a sustainable safety culture in an enterprise.

The dissertation provides recommendations how to improve the OH&S situation at the state and enterprise level. The thesis suggests several possible

approaches in managing safety knowledge, which can be used by senior managers, particularly in manufacturing SMEs. The study proposed a model of safety culture with KM dimensions as an effective management tool for change and diagnosing the safety culture; to focus more directly on CoP as a source of safety culture and as the 'one important focus'of (collective) learning, transmitting practical safety knowledge as well as through managing the safety social capital inherent in an organization.

This thesis also attempts to contribute the author's own views and suggestions by enhancing employers' and employees' awareness and drawing public attention towards weaknesses in the relevant Estonian OH&S system, challenges in OHSMSs, unsafe working conditions and acts, as well as towards the implementation of the relevant regulations and labour legislation in SMEs. To address the recorded negative perceptions and challenges in the work environment in Estonian SMEs, a genuine and substantial change in management's attitude with an increased commitment to employees' health and safety must take place.

The findings from the current dissertation are important from a practical standpoint in the working environment. The questionnaire and interviews revealed aspects of senior managers' and employees' safety attitudes and perceptions which were directed towards safety culture. The results from the thesis study and, in particular from the evaluation of working conditions (real safety state), based on workplace observation, audit and risk assessment (data about exposure to occupational hazards and existing preventive measures), are of vital importance for management in manufacturing SMEs, safety and strategic management researchers who perform studies in SMEs as well as for lecturers, students, occupational health and safety professionals (i.e. occupational physicians, hygienists, ergonomists, etc), and safety managers at the enterprises, as well as for decision-makers at the sectoral organizational and state level.

The originality of the studies lies in the usage of the data from a small open economy of Central and Eastern Europe, the Baltic state of Estonia. The thesis provides an insight into the necessary mix of regulation and self-regulation in the management of OH&S at enterprise level and offers an insight into the balance between the two to achieve effective and sustainable safety cultures in an economy dominated by SMEs. It thus has potentially wider applications in the field of OHSM.

## 4.3.    Validity and reliability of the study

*The qualitative study*

Reliability and validity assessment in qualitative and quantitative research differ. According to Yin (2003) there are four types of tests to be conducted in case study research: construct validity, internal validity (only for explanatory or

causal studies), external validity (whether the findings can be generalizable beyond the immediate case) as well as reliability /whether a later research would arrive at same findings as the earlier research by repeating the same study). The validity of the current qualitative study is evaluated below in terms of this categorization, with the exception of internal validity, since according to Yin (2003) it is not relevant in exploratory case studies. Multiple source of evidence ensured the construct validity of the study, evidenced in the number of interviewees in each organization as well as in the multiple sources of analyzed data (for instance, secondary data in the form of relevant health and safety documents, homepages, risk assessment and audit reports). The case-study reports were sent back to enterprises for review (as recommended also by Eriksson and Kovalainen, 2008). In addition, replication logic was used in order to ensure external validity specifically literal replication (choosing cases were expected to provide similar results on certain issues): eight reasonably similar manufacturing SMEs. Yin (2003) suggests that multiple case studies should be generalizable to the theory.

The current qualitative research judges validity and reliability within the constructivism paradigm which views knowledge as socially constructed and may change depending on the circumstances (Golafshani, 2003; Crotty, 1998). The main aim of the qualitative research is to "engage in research that probes for deeper understanding rather than examining surface features" (Johnson, 1995, p4) and constructivism may facilitate this aim (Golafshani, 2003). Since "constructivism values multiple realities that people have in their minds" (Golafshani, 2003, p 604), to acquire valid, reliable and diverse construction of realities, multiple methods (observation, interviews and recordings) of gathering data are vital. Thus, the use of triangulation in the constructivism paradigm is appropriate (Johnson, 1997; Golafshani, 2003). Triangulation is accepted as a way to ensuring the comprehensiveness of findings within a set of qualitative data. This strategy reduces the risk of chance associations and of systematic biases due to a specific method and allows a better assessment of the generality of the explanations that one develops (Golafshani, 2003). The most extensive discussion of triangulation as a validity testing strategy in qualitative research is by Fielding and Fielding (1986). At the same time, several researchers argue that triangulation is more applicable to ensure comprehensiveness of findings rather than truthfulness and validity (Mays and Pope, 2006). As suggested by Eriksson and Kovalainen (2008), the current research applied triangulation forms related to the data (cross-checking information by using multiple empirical sources), to multiple methods of data collection (mixed methods) and data analysis (several researchers examined the materials). The use of mixed methods permits triangulation of the data to improve the validity of the findings, and enabled greater inferences from the results. This is especially important in the study of OHS due to its multidisciplinary nature (Glendon et al., 2006). Reliability in qualitative research aims at minimizing errors and bias. To ensure reliability in qualitative research, examination of trustworthiness is vital (Golafshani, 2003).

The current research applied procedures in order to increase reliability of the study (Yin, 2003; Silverman, 1998) as follows: careful maintaining of documentation, using a case-study database in the collection process; reporting the interview questions and keeping an electronic database covering all the case-study material and the analysis; audio-recording of the interviews and their transcripts using standard conventions meets the demand of documenting the data collection procedures.

The research involves ethical conduct toward the study participants, which includes conscious consent to the study (means that respondents must decide whether to participate in the study), confidentiality (requirements set for the process of conducting interviews by respecting the respondents and the things and perception they share as well as for data storage); anonymity (means that the respondents and informants' names are not mentioned in the study) and the consequences of the study (which the researchers cannot foresee, but the aim is to protect the interviewees' anonymity) (Virta, 2011).

*The quantitative study*

The quantitative data of the current research consist of a survey comprising two parts: the longitudinal studies of occupational health professionals (conducted in 2002 and 2009) and data acquired from a national Work Environment questionnaire survey, conducted by Statistics Estonia in 2009. The survey instruments for longitudinal studies consisted of validated measures found in the scientific literature, measures that were modified, also some new items. The items that were originally in English were first translated into Estonian and Russian and then back-translated in order to ensure the reliability of these items. The questionnaires for occupational health professionals were pretested to ensure the reliability and clarity of the items.

Secondary data were acquired from a national Work Environment questionnaire survey, conducted by Statistics Estonia, which is a representative survey utilizing employer-employee-linked data, designed specifically to study working environment and to measure safety climate, safety attitudes, perceptions, values, conflicts and relationships, information dissemination, job satisfaction, responsibility and commitment, risk awareness, working conditions, and safety measures. The current survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. The initial population comprised a cross-industry sample of Estonian manufacturing SMEs, which included all enterprises with not more than 249 employees. The data were used in three publications (Article V-VII). The statistical analyses conducted for the data were similar for the purposes of both Publications VI and VII. Once the theoretical model was built, the theory-based items were subjected to exploratory factor analysis. Loading and communalities were checked. Based on the results of the exploratory factor analysis, composite measures were built of the items. Due to time limitations, the reliability of multi-item variables was not tested for the current study. The testing of the reliability

of multi-item variables using Cronbach's Alpha (Nunnally, 1978), which is used to measure the internal consistency of scales, remains for the future analysis. The greater the alpha-value is, the more coherent the instrument. The reliability test and regression analysis are an essential set of analysis planned for the future research.

## 4.4.    Study limitations and future research

This study has some limitations to be addressed. First, there are methodological limitations. The use of both qualitative and quantitative approaches within the same study has offered the possibility of exploring the phenomenon. Even though, Quinn and Spreitzer (1991) reference the debate over qualitative versus quantitative methodologies for studying organizational (safety) culture, one of the limitations of using qualitative research methods has been the inability to compare culture dimensions across organization and it is difficult to identify safety activities and behaviors that would apply to all employees and employers throughout the investigated organizations in the manufacturing sector. In addition, eight case studies (observations, audits, risk assessment), and a limited number of interviews may represent a small sample. Thus, further research with a larger number of people, including safety managers, must be conducted. This study was not designed for the results to be generalized to other SMEs. However, the results are likely to have applications for the other manufacturing SMEs operating in Estonia. The thesis identified commonalities in the need to improve the contribution of safety knowledge to safety management processes and practices in a selected sample of Estonian SMEs in different economic sectors, suggesting that while there may be some variations between sectors in the application of safety knowledge, further economic benefits and improvements in employee well-being could be secured across all sectors reviewed by creating the appropriate conditions in which to embed a sustainable safety culture in enterprise management systems.

It was assumed that respondents were honest and provided meaningful survey responses. At the same time, the quantitative data were self-reported, which is affected by information bias and recall bias, especially in relation to reporting of occupational injuries, illness and accidents (Loughlin and Barling, 1998; Pransky et al., 1999; Barling et al., 2002). However, self-reported data are commonly used in social sciences research, especially during the initial exploratory stage, and can provide important complements to quantitative observational measures (Shaw et al., 2001a,b). Previous research on the OH&S of safety culture has often used self-report data.

Although there are many advantages of interviewing to collect the OH&S data, the adoption of face-to-face interview methods also introduced potential interview bias, which was taken into account and attempts were made to eliminate them during the interview procedure. In addition, some researchers claim that the focus groups interviews are not a good research methodology

because of the potential influence of one or two respondents on the remaining members of the group. These critics claim that a dominant respondent can negatively affect the outcome of the group and that group pressures may influence the comments made by individuals (Wimmer and Dominick 1997, p 461).

As all the data in the current study have been gathered from a single country, Estonia, it poses some limitations to the generalizability of the results. The legal system in Estonia is different from other countries. However, the results are in these terms somewhat generalizable to other countries (for instance to Baltic countries as a post-communist newer European Union Members) with similar legal systems and common history.

Despite these limitations, this study revealed findings that have both theoretical and practical significance. Of particular importance are the implications that these findings have for both safety culture and organizational science research. From a more practical standpoint, it is likely that senior managers can benefit from a balanced approach to safety that includes traditional safety management activities (i.e. management of physical or tangible resources/ assets, such as safer technology, regular audits, hazards identification, proper risk assessment; use of less hazardous chemicals and the elaboration of safe procedures, safety policies and guidelines etc), but special attention should be given to intangible resources/assets which comprise what we have called here, the communities of practice (i.e. employees' capabilities, competence, skills, organizational and safety culture, the company's image, an organization's resources and way of action and the relationships).

**Future research**

Future studies can also adopt different safety culture indicators to examine and validate the proposed model of safety culture. Future research is needed to evaluate whether measuring additional domains such as teamwork climate, perceptions of management, or stress recognition is useful. Future research should pay more attention to understanding how organizational values are used in an organization and which factors are affecting their implementation in the organization.

Another kind of study approach would be more suitable for probing deeper into safety culture issues at the organizational level, focussing on safety performance and the actual behavior, safety promotion, safety policy and procedures, safety awareness, creation and transfer safety knowledge. This study was exploratory and as such, the next step should explore in detail the relationship between the safety culture dimensions and managing safety knowledge, how it relates to accident rates and safety performance, also in other studies (Fernandez-Muniz et al., 2007; Grote, 2008; Grote and Künzler, 2000; Silva et al., 2004; Vredenburgh, 2002).

In addition, it would be useful to study how  an organization can support collective learning in the field of OH&S as well as on identifying the relevant organizational indicators of safety culture, measuring safety culture and organizational values, how these are interrelated and change over time especially in SMEs. It would also be valuable to obtain information on the safety managers, occupational health and safety professions, to evaluate the effect of some safe working practices.

Based on the thesis study, the author emphasizes that further research should consider essential aspects in the process of the evaluation of safety culture, like organizational, human and social perspectives in safety. In addition, it is vital to include both quantitative and qualitative studies in order to gain a thorough understanding of the complex phenomenon towards understanding safety culture and ultimately improving employees' safety. The use of structured interviews and focus group interviews could be useful, specifically for each of the economic sector in SMEs. The questions should be carefully analyzed and prepared in order to gather required knowledge. For instance, the communication questions concerning the types of communication or frequency of communication, did not evaluate the quality and effectiveness of communication. It is not known whether the safety managers or supervisors discussing safety are purely giving lip service or whether their practices are consistent with the conversations they have regularly.

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# Appendix 1.

**Research paper I**

Reinhold, K., Järvis, M., Tint, P. (2009) Risk Observatory - A Tool for Improving Safety and Health at the Workplace. *International Journal of Occupational Safety and Ergonomics*, Volume 15, No 1: 101-112. (ETIS 1.1)

# Risk Observatory—A Tool for Improving Safety and Health at the Workplace

Karin Reinhold

Marina Järvis

Piia Tint

Tallinn University of Technology, Tallinn, Estonia

*The main problems in occupational health and safety (OHS) system in Estonia (a postcommunist new European Union Member State) are analyzed and the implementation of a simple, flexible risk assessment method is presented. The study aimed to assess the working environment, the employers' possibilities and willingness to carry out risk assessment, ways to manage risks and the steps being taken towards progressive improvement in OHS. The role of the Estonian Labour Inspectorate in the risk observatory is that of the main key authority in data collection and information dissemination in OHS.*

occupational health and safety    risk assessment    working conditions

## 1. INTRODUCTION

This article provides an in-depth analysis of a postcommunist new European Union (EU) Member State, Estonia, situated in the Baltic region, on the southern shores of the Gulf of Finland. Despite its physical proximity to its northern Scandinavian neighbour of Finland, Estonia lacks many progressive features of the system of safety culture and risk assessment which prevails there [1]. The purpose of this paper is to illustrate the contours of a gulf which constitutes not merely a geographic separation, but a separation of standards in occupational health and safety. We attempt to illustrate this theme by workplace-based data on risk assessment and risk management and to assess the steps being taken towards progressive improvement in occupational health and safety (OHS).

Estonia is one of the smallest countries in the enlarged EU (population: 1.4 million; labour force: 600 000). Like many other European countries, especially postcommunist ones, it has an aging labour force, which poses ongoing problems in terms of meeting urgent changes in the economy. Work pressure and the stress in daily life are perceived as creating health problems both at the workplace and during leisure time.

The incidence of occupational diseases is a specific indicator of existing hazards and risk factors in the working environment. In Estonia, occupational diseases are mainly registered in their later stages when the patient is already incapacitated. The main causes of occupational diseases at present are identified as arising from lifting heavy loads and from repetitive forms of work. Both cause musculoskeletal disorders.

## 2. RISK ASSESSMENT IN THE WORKING ENVIRONMENT

Risk assessment in the working environment has been a topic for Estonian OHS researchers since 1996, i.e., since the publication of "Guidance of risk assessment at work" [2]. The OHS Act, which

requires risk assessment to be carried out at every workplace, was adopted in Estonia in 1999 [3].

Existing risk assessment models (based on Standard No. BS 8800:1996 [4]) indicate the need to determine the probability of occurrence and the severity of the consequences of the impact of hazardous factors on the worker. It is difficult for employers to determine those probabilities (in Estonia risk assessment can be carried out by employers or by a person or an office recognized by the Health Care Board). Pekkarinen has discussed some versions of risk assessment in Standard No. BS 8800:1996, where the probabilities are clearer for the user [5]. The need to set correlations between exposure time and stages of occupational diseases is very obvious. Rantanen has developed a model for determining the level of risk for chemical hazards (considering exposure limits in Standard No. BS 8800:1996 [4]) [6].

A simple, flexible risk assessment method has been worked out at the Tallinn University of Technology [7]. It is based on a two-step model that can be enlarged. This model offers every enterprise an opportunity to choose a suitable and feasible scheme for implementation into practice. The practical use of the model is given in section 4.

## 3. THE ACTIVITIES OF THE NATIONAL LABOUR INSPECTORATE (NLI) IN RISK OBSERVATORY

The NLI is the main and the only administrative body in OHS in Estonia. It provides surveillance over legislative compliance, records occupational accidents and diseases on a yearly basis, and inspects hazards in the working environment. As there are ~60 000 small and medium-sized enterprises (SME) in Estonia, the NLI (with only ~40 labour inspectors) has the capacity to inspect only those which deal with hazardous activities or where a serious accident has been reported. Like in many other European countries, SMEs are a problem area for Estonian OHS because their owners often lack knowledge on risk assessment and risk management.

## 3.1. The Situation in OHS in 2002

This section compares the working environment issues in Estonia in 2002 [8] and 2006 [9]. This analysis shows how the goals for improving working environment have changed during those 5 years.

The strategy for the Estonian OHS for 2002–2006 tried to follow the EU strategy for that period [10]. The NLI plans its future annual activities on the basis of the results of working environment assessments and an analysis of occupational accidents and diseases registers of the current year, including the implementation of campaigns proposed by the European Agency for Safety and Health at Work, e.g., on construction safety.

Since 1999, when the OHS Act came into force, the NLI has exercised systematic control over compliance with the requirements of the law in companies and institutions. Considering the variety and the level of hazards in Estonian enterprises and taking into account the human capacity of the NLI (100 workers, 40 of them labour inspectors), state supervision and working environment assessment covered first and foremost larger enterprises with more hazardous fields of activity. The frequency of inspection of these enterprises in the future is to be determined by the level of hazards identified in the enterprises during previous assessments.

Assessment of the working environment in enterprises is a labour- and time-consuming activity. Therefore, target inspections or campaigns are planned and carried out each year with the aim of covering as many enterprises as possible where there is a likelihood of specific OHS problems. During target inspections measures are taken to eliminate or to reduce the hazards and health risks.

Inspection priorities and objectives for 2002 were as follows:

- to ensure that the working environment complies with the requirements of legal acts regulating OHS in enterprises with more hazardous working environments (manufacturing industry; mining industry; construction; electricity; gas and water supply;

transport, storage and communication; fishery; forestry and agriculture);

- to inspect and assess those enterprises in hazardous areas of activity with 10–19 employees that were not inspected in 2001;
- to inspect new and reconstructed buildings and to advise employers as to what is needed to ensure workplaces [11] and work equipment [12] comply with OHS requirements and that work arrangements are in line with the requirements of legal acts;
- to inspect activities focussed on risk assessment in the food industry to reduce the risk caused by physiological factors, thus primarily improving the working conditions of female workers;
- to inspect implementation of the requirements of the working and rest time act (WRTA) [13] and the employment contracts act (ECA) [14] to ensure that the requirements of the legal acts regulating labour relations in the construction industry are followed, thus preventing incapacity and illness of construction workers caused by physical and psychological stress;
- to inform employers who cannot be directly inspected in 2002 about of new legal acts regulating OHS and labour relations, thereby directing employers' activities towards complying with the requirements and, as feedback, obtaining information from the employers of the measures taken to improve the working environment in the enterprises;
- to continue the inspections in the enterprises with more hazardous areas of activity (as revealed by inspections in 2001); enterprises where there were serious or fatal occupational accidents, or where cases of occupational diseases were registered; in the course of follow-up inspection, to assess the changes that have taken place in the working environment and assess the results of activities to prevent accidents and ill health at work.

Four types of inspections (general, advisory, target and follow-up) were carried out by the NLI. In 2002, 4 734 enterprises were inspected; in 1 661 of them the employer's activity was assessed in terms of compliance with legal obligations, and in 1 358 the working environment as a whole was assessed (general inspection). Inspection of compliance with legal acts regulating labour relations was also carried out during general OHS inspections, and in 597 enterprises, during target or follow-up inspections. During advisory inspections 669 employers were informed of new OHS-related legal acts.

Target inspections concerning the assessment of physiological risk factors took place in 102 enterprises in the food industry, and in 132 enterprises and on 162 construction sites, where they concerned WRTA [13] and ECA [14] requirements. The reports of the target inspections were submitted to the Ministry of Social Affairs and to the respective employers' and employees' organizations to promote social dialogue.

In 1 508 new or reconstructed buildings compliance with OHS requirements was assessed through inspection before local government authorization for use were granted and compliance of personal protective equipment (PPE) with safety requirements was assessed in 65 enterprises. During these inspections work was halted in 24 cases where it was assessed as dangerous to the life of workers or other persons near-by and in 88 cases the use of life-threatening work equipment was forbidden.

The causes and circumstances of 839 serious and 26 fatal occupational accidents were investigated in collaboration with the police and labour inspectors who participated in the investigation of 236 serious occupational accidents, of which 141 resulted in prosecution for OHS law violations. In addition, 98 cases of occupational disease were investigated with the participation of occupational health doctors (of whom there are ~100 in Estonia).

Advice was given by the inspectors to 6 613 employers and 10 652 employees or their representatives as to how to solve problems concerning OHS and labour relations. A total of 418 written petitions of employees were examined and resolved. On the basis of the ECA [14] and WRTA [13] 6 791 applications to conduct commercial operations were granted to employers concerning 57 844 employees. In 801 cases such applications were rejected.

For violation of the requirements of legal acts administrative penalties were imposed on 184 natural persons (individual employers or their representatives), the total sum of fines: 138 880 EEK (8 860 EUR); and to 30 legal persons (registered commercial legal entities), the total sum of fines: 185 000 EEK (11 800 EUR). This gives an average of penalties imposed as 48 EUR and 393 EUR, respectively, during this period.

## 3.2. The Report in 2006

NLI's report for 2006 shows the changes in OHS goals during the first years of Estonia's membership in the EU. NLI's priorities in 2006 were as follows:

- surveillance of major hazardous enterprises and as many as possible enterprises using hazardous chemicals; enterprises with potentially explosive atmosphere and where overall control had not been carried out in 2003–2005;
- surveillance of other hazardous activities (wood processing; processing of metals, equipment and machines; chemicals or chemical products; food processing) and enterprises where there had been accidents in the past 2 years.

In 2006 the problem of asbestos was highlighted. In this context 32 asbestos-using workplaces were checked, of which 18 were engaged in manufacturing asbestos-cement products and 9 in asbestos management. Inspections were done in co-operation with Finnish and Estonian OHS researchers.

Surveillance in 2006 was intensive with 5 982 NLI inspections, an increase of 26% from 2002 and 19% from 2005. Over 3 300 employers received formal notifications of OHS requirements to be met. General inspections were carried out in 824 enterprises, a decrease of 39% from 2002 and 44% from 2005.

Target inspections were made in 2 592 enterprises (the day of inspection was not announced in 1 162 visits). A new method of inspection was also developed: speed inspection. This kind of control which involves a brief

visit of up to one hour by a labour inspector in accordance with a list of medium to low risk working environments (according to a list compiled by NLI) was carried out in 1 034 enterprises. The number of follow-up inspections where violations were noted increased from 717 to 804 from the previous year.

The different distribution of inspection activities carried out by the NLI in 2006 compared to 2002 was as follows: general inspection: 16% (28% in 2002); speed inspections: 17% (nonexistent in 2002); target inspections: 43% (35% in 2002); inspection of new buildings: 12% (31% in 2002); follow-up inspections: 12% (6% in 2002).

During the inspections, 11 666 legislation violations were found; 8 655 orders for remedial action were issued and 3 011 recommendations were compiled to help employers to improve the working conditions.

The pattern of violations, with failure to carry out risk assessment in the first place, comprised (a) risk assessment not carried out by the employer, 1 633 cases (11%); (b) internal audit not carried out, 1 286 (8%); insufficient training and safety instructions, 992 (6%); safety instructions not compiled, 813 (5%); nobody elected and trained to be responsible for first aid, 730 (5%); and no safety representatives elected 619 (4%).

Several conclusions emerged from these data:

- employers did not ensure OHS in the workplace was at the required level;
- co-operation between employers and employees on OHS matters was insufficient;
- deficiencies in OHS systems in enterprises continued to cause accidents and occupational diseases.

The following pattern emerged in an analysis of legislative violations in the use of work equipment and in the organization of work tasks:

- in 965 cases, the work tools did not correspond to the norms; of those, in 283 instances, equipment did not correspond to the safety demands, and in a further 123 instances, safety control equipment was out of order;

- in 1007 cases, workrooms and workplaces (including computer workstations and pathways) were not arranged in accordance with the legislation;
- in 232 cases, hazardous areas, pathways and containers were not properly identified.

The following pattern emerges from an analysis of legislative violations concerning environmental hazards:

- in 417 cases, there were violations concerning chemical usage (including cases where chemical safety cards were absent, contamination in the workrooms was not measured, requirements for working in explosive environments not followed;
- in 355 cases, the legislation act on lifting heavy loads [15] was not followed and risk analysis was not conducted;
- in 223 cases, measures to decrease harmful physical environmental factors were not followed, e.g., lighting was below stipulated norms.

The strategy of inspection (first, primary inspection and, if the NLI inspector deemed it necessary, a follow-up inspection) worked. Most employers corrected their mistakes by the follow-up inspection.

During the primary inspection the enterprises were divided into three groups according to how safe the working conditions were: low (22%), medium (58%) and high risk (20%). During the follow-up inspection the inspectors noted that the proportion of low risk enterprises increased and of medium and high risk enterprises decreased (Figure 1).

## 3.3. Changes in 2002–2006

Risk assessment as a tool for decreasing occupational accidents and diseases was emphasized between 2002 and 2006. NLI's strategy changed to more target inspections than unannounced visits to enterprises. The number of occupational accidents increased (from 3 115 in 2002 to 3 651 in 2006). The size of the workforce changed from 585 500 (532 accidents per 100 000 workers) to 646 300 (565 accidents per 100 000 workers) during this period. It would appear that fewer accidents were hidden. The number of fatal accidents decreased marginally from 5.0 to 4.5 per 100 000 workers as there were
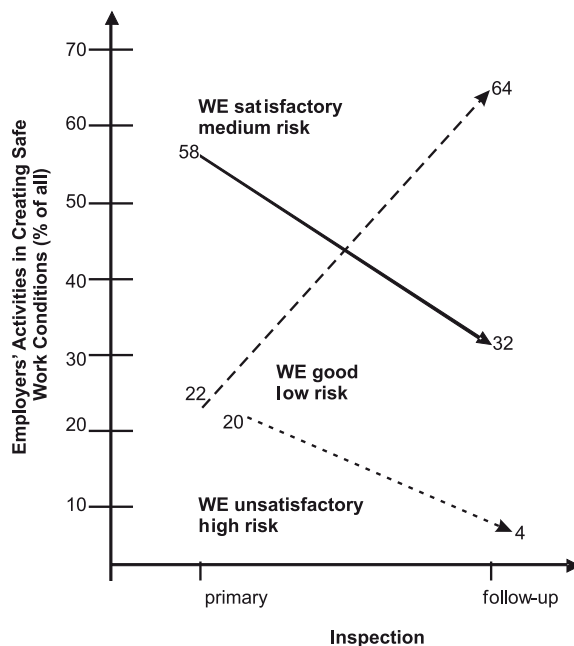


**Figure 1. National Labour Inspectorate's assessment of the impact of primary and follow-up inspections.** *Notes*. WE—working environment.

fewer industrial activities (mostly construction work).

In the next section we show the practical use of the risk assessment model in industrial and office environments.

# 4. THE PRACTICAL PART OF THE INVESTIGATION

The Ergonomics Laboratory of the Tallinn University of Technology carried out risk analysis in 143 Estonian enterprises and offices in 2002–2008. About 3 000 workplaces were investigated. In most cases, the risk assessment method was based on Standard No. BS 8800:1996 [4]. In addition, workers' opinions on hazards in their working environment were gathered [16, 17, 18].

## 4.1. Analysis of Working Conditions in the Wood Processing industry

The working environment in a large wood-processing firm (1 000 workers) in a medium-sized town in Estonia was analyzed. A list of hazards had been compiled prior to the investigation by the firm's working environment specialist with over 20 years' work experience in this factory. The main risk factors were hazardous tools and equipment, heavy physical load (moving wheelbarrows), noise, wood dust and, occasionally, chemical odours (e.g., formaldehyde) originating from polishes. Some indication of the overall level of safety culture can be gained from the discovery that one protective metallic machine guard for protection against cut injuries to fingers had been removed and replaced by cardboard. This type of accident has predominated in Estonian work traumas in recent years (~500 cut injury traumas of fingers per year are reported, including amputations).

Hazards were measured in the polishing and varnishing department: air temperature: 19.8 °C; air humidity: 42.0%; lighting (overall): 300 lx; wood dust concentration: (a) ~1.5 mg/m$^3$ overall in the department, (b) 10.0 mg/m$^3$ near the machines; noise: 98.0–101.2 dB($A$); concentration of formaldehyde (as a component of phenol-formaldehyde varnish), an 8-h mean: 0.5 mg/m$^3$.

Vibration caused by wood-processing equipment was not measured. However, the vibration disease in the wood industry in Estonia is rather high (one of the two most frequent occupational diseases, alongside physical overload).

On the basis of the measurements and observations in the department the following conclusions were made.

- The microclimate in the polishing and varnishing department met the requirements; however, it would be reasonable to raise the moisture content of the air to avoid workers' complaints of itchy eyes and dry skin.
- Noise was above the limits, 85 dB($A$), in every workstation measured, but work breaks were taken and earmuffs were used. Thus, the total amount of noise during an 8-h workday did not exceed the permissible level (dose: 85 dB($A$) × 8 h).
- Phenol-formaldehyde varnish is an allergen. The risk phrases for this compound are R23/24/25, R34, R40, and R43 [19, 20]. The exposure limits (0.6 mg/m$^3$) were not exceeded, but the welfare of sensitive workers has to be considered.
- The safety of machines has to be taken into consideration when buying new equipment. Experience shows that even machines with CE-mark can cause traumas if used incorrectly.

The 5-step simple, flexible risk assessment model was used for assessing working conditions (Figure 2).

## 4.2. Analysis of Working Conditions in the Textile Industry

The working environment in a middle-scale textile firm (200 workers) in Tallinn was analyzed. The list of hazards was compiled before the investigation by the working environment specialist of the enterprise.

The main risk factors in the textile industry include hazardous tools and equipment, heavy physical load and adverse ergonomics primarily for female workers, noise and textile dust. Hazards were measured in different departments (sewing, cutting

noise (98.0 dB (*A*))
wood dust
(10.0 mg/m$^3$)
physical overload

air humidity
(42.0%)
formaldehyde
(0.5 mg/m$^3$)

air
temperature
(19.8 $^\circ$C)

| inadmissible | unjustified | justified | tolerable |
| risk | risk | risk | risk |
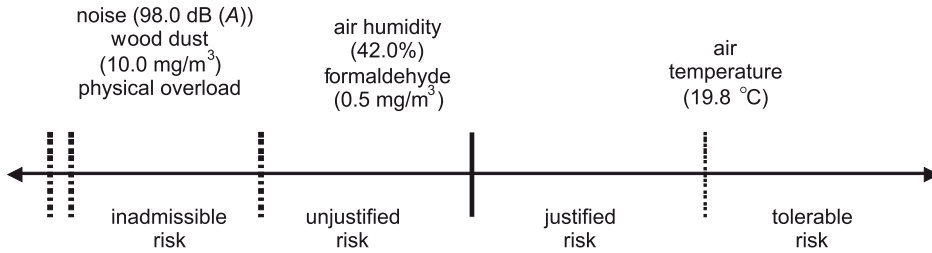
**Figure 2. Assessment of the working conditions with a simple risk assessment method in the wood processing industry.**

and embroidering): air temperature: 20.0–26.7 °C; air humidity: 33.0–38.0%; lighting: 160–1 900 lx; textile dust concentration: (a) ~0.4 mg/m$^3$ overall in the department, (b) 1.0 mg/m$^3$ near the machines; noise: 70.0–89.5 dB(*A*).

Because of the possibility of accidents/traumas originating from machines, it was declared that there were hazards for finger traumas. As mentioned before, those traumas are frequent in Estonia. Therefore, the safety of equipment has to be taken into consideration when purchasing new sewing and button machines.

On the basis of the measurement and observations in the department the following conclusions were made.

- The microclimate in the textile firm was satisfactory (although there was still scope for improvement by raising air humidity and providing better ventilation).
- Noise was under the permissible limits, 85 dB(*A*), in most workplaces, only in a few areas was it higher than 85 dB(*A*), but breaks were taken and earmuffs were used if necessary.
- Therefore, the total amount of noise during an 8-h workday did not exceed the permissible level (dose: 85 dB(*A*) × 8 h).

The 5-step simple, flexible risk assessment model was used for the assessment of working conditions (Figure 3).

Most of the offices investigated belonged to industrial companies, but workrooms of educational institutions (kindergartens, schools and the Tallinn University of Technology) were investigated, too.

The working conditions in offices, where people spend whole workdays in front of video display units (VDUs), vary greatly between seasons because of changes in overall ambient lighting. Poor knowledge of VDU-related ergonomics was one of the most salient problems in modern or recently renovated offices.

Other concerns in renovated offices were insufficient ventilation (adjustment and air flow problems as well as problems with defective separation of fresh and used air), problems with lighting (glare, unsuitable colour temperature of the luminaries, low or no daylight factors, etc.), poor microclimate, particularly in summer, and noise. Those problems were not addressed when planning renovation work in the offices.

There are numerous unrenovated offices in Estonia, too, with poor microclimate (cold air),

noise (89.5 dB (*A*))
air temperature
(26.7 $^\circ$C)
physical overload

air humidity
(38.0%)
textile dust
(1.0 mg/m$^3$)

lighting
(500–1900 lx)

| inadmissible | unjustified | justified | tolerable |
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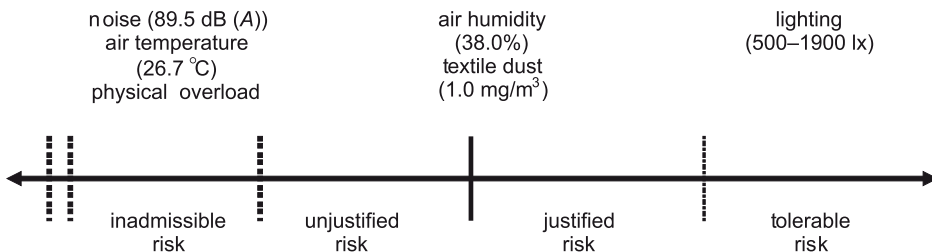
**Figure 3. Assessment of the working conditions with a simple risk assessment method in the textile industry.**
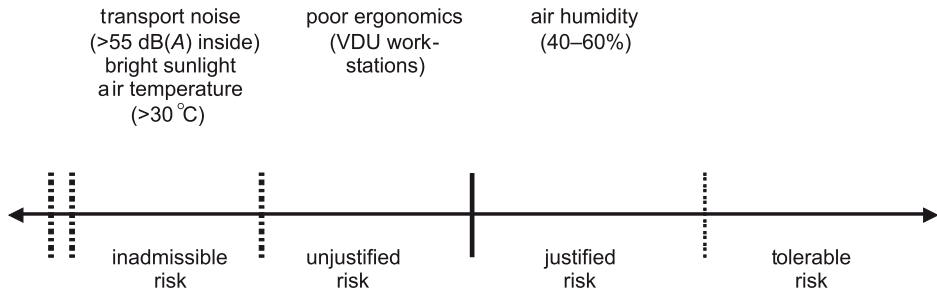
**Figure 4. Assessment of the working conditions in offices in summer.** *Notes.* VDU—video display unit.
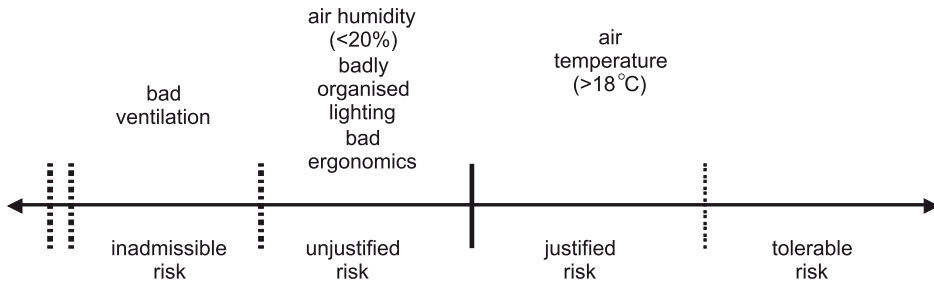


**Figure 5. Assessment of the working conditions in offices in winter.**

ventilation problems because of dirty ventilation ducts which are not cleaned regularly, insufficient lighting, and poor ergonomics.

It is important to consider these problems during planning renovation as otherwise, workers' concerns will emerge with even greater urgency when they have to face the same problems in renovated areas. The workers' age also has to be taken into account, because older personnel tend to have different concerns than younger ones.

The 5-step simple, flexible risk assessment model was used for the assessment of the working conditions in offices in summer (Figure 4) and in winter (Figure 5). Different offices were surveyed in summer and winter.

## 4.3. Conclusions on Exposure

Working conditions in the Estonian working environment vary a great deal. In the best cases, economically successful firms are able to supply their workers with a sauna, solarium, gym, etc., but in others, conditions can be at the opposite extreme, e.g., workers have to work in freezing conditions (at 0 °C inside the room in winter) or workers' personal clothing is hung where there are odorous chemicals.

Working conditions tend to be better in commerce and banking; however, in manufacturing, they may still be quite poor. Moreover, there is considerable regional variation. In the capital and the surrounding areas enterprises have the capacity and finances to invest in workers' health more than in the other regions. However, despite the distance which remains to travel before the best Scandinavian practice becomes general, working conditions are improving from year to year.

New Estonian legislation on occupational health and safety which is based on EU directives has produced a positive, if still uneven, impact in terms of improving working conditions and increasing the level of safety culture. Workers themselves appear to have begun to realize that OHS cannot be left entirely to safety personnel if there is to be active implementation of safety and health measures. The spread of information throughout the organization and a positive attitude towards safety among the workforce are extremely important.

More essential problems occur at the level of SMEs (the overwhelming majority of Estonian enterprises), where the problems are often dealt with only after there has been an accident. Large enterprises usually employ a specialist in OHS educated in legislation, management of hazards and in prevention.

Many workers in Estonia do not report symptoms of ill health and continue to show up for work. In addition, individuals continue to accept their problems as a consequence of aging or fatigue and do not often perceive their problems as work-related.

## 4.4. Workers' Opinion on Working Conditions

During visits to enterprises and offices to measure the working environment and to assess risk, an attempt was made to elicit employee views. In 50% of cases (~70 enterprises) a short questionnaire (in Estonian and Russian) was administered; response rate was 24% (i.e., 356 completed questionnaires). The results are given in Figures 6–8. Ergonomic hazards were to be ranked on a 4-point scale: do the following hazards create a problem for you *often*, *sometimes*, *seldom* or *never*.
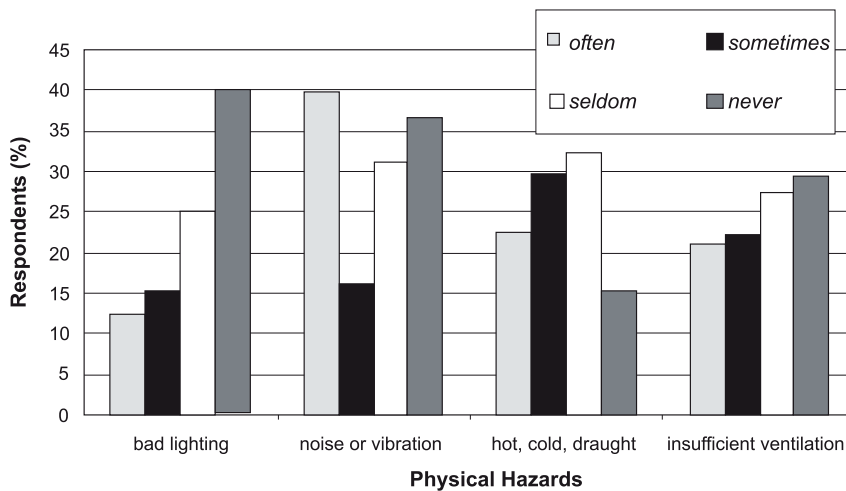


Figure 6. Workers' opinions (*n* = 356) on physical hazards in the working environment.
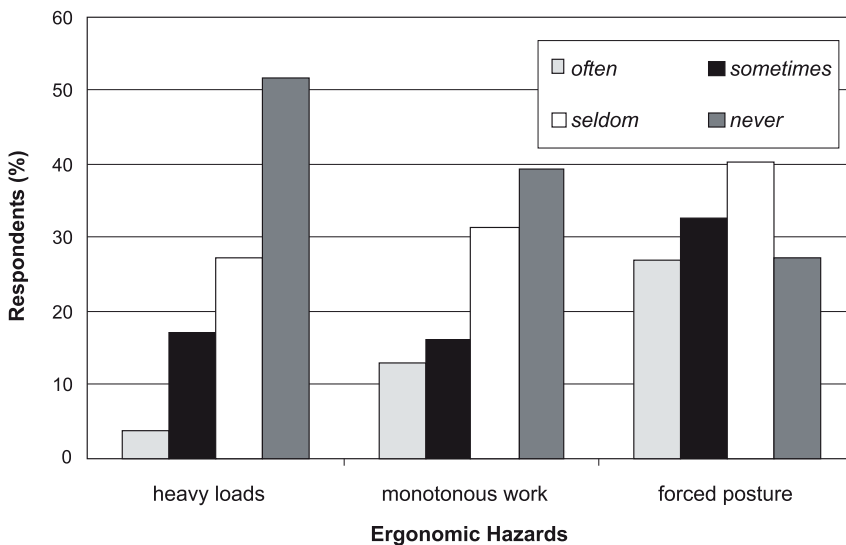


Figure 7. Workers' opinions (*n* = 356) on ergonomic hazards in the working environment.
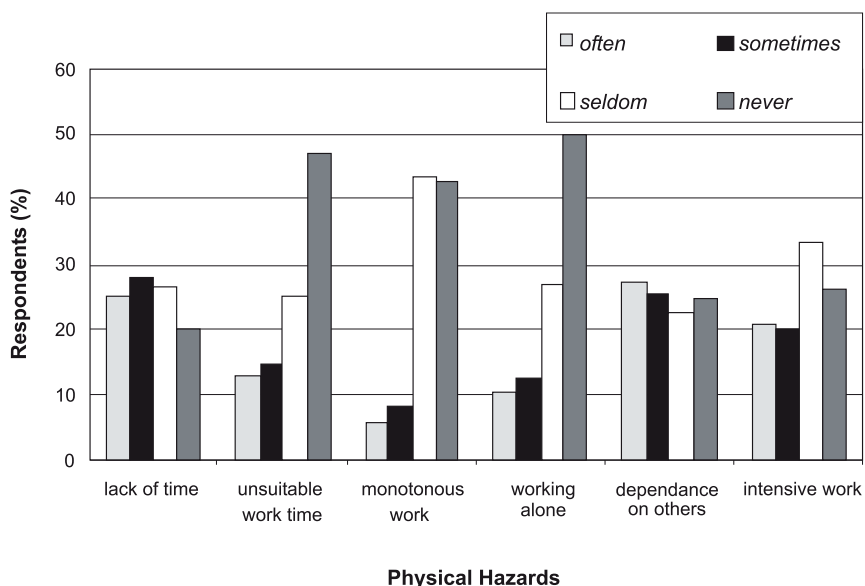
**Figure 8. Workers' opinions (*n* = 356) on psychological hazards in the working environment.**

Workers mostly complained about excessive noise, forced postures, lack of time (due to intensive working pace) and the dependence in the work process on colleagues. One in five complained of the intensity of the work process itself.

The following conclusions can be drawn on the basis of a comparison of those figures with data from the Baltic Working Environment and Labour (BWEL) survey [21].

- Both studies produced the same results regarding problems with lighting: poor lighting in the current study elicited *often* as a problem for 12.5% of workers and *sometimes* for 15.0% of workers; in BWEL poor lighting was *a serious problem* for 8.2% of workers and *a minor problem* for 24.9% of workers. Some differences appear when comparing the influence of noise: in the current study the noise and vibration load affected *often* 40.0% and *sometimes* 15.0% of workers; in BWEL noise and vibration were *a serious problem* only for 11.2% and *a minor problem* for 27.8% of workers. Noise is a problem characteristic for many manufacturing branches such as printing, wood processing, textile industries,

whereas it might not be a problem for office workers. As the current study examined mainly noisy industrial branches, the differences might have resulted from this factor. Microclimate problems arose more explicitly in the current study than in the BWEL survey as extreme temperatures disturbed *often* 22.5% and *sometimes* 30.0% of workers, while in BWEL inappropriate or inadequate air temperature control was *a serious problem* for 10.7% and *a minor problem* for 22.4% of workers.

- Both studies indicated that Estonian employees frequently faced poor ergonomic conditions at work: the most negative factor in the current study was forced postures that affected *often* 28.0% and *sometimes* 32.0% of workers. In the BWEL survey, the comparable factor was overall fatigue that affects 33.1% of the Estonian workers.

- The current study showed that according to the workers lack of time (*often* 25% and *sometimes* 28.0% of workers) and the dependence of the work process on colleagues (28.0% of workers *often* and 26.0% *sometimes*) were the most negative factors related to psychological conditions. In the BWEL study, psychological

factors were summarized with one indicator, stress, which affects 24.4% of workers.

## 5. CONCLUSIONS

The European Commission has set for itself an ambitious overall objective: to reduce by 25% the total incidence rate of accidents at work in the EU in 2007–2012. This will be a great challenge for Estonian OHS.

The Estonian working environment has changed considerably during the last 10 years and is continuing to evolve as a result of the following trends much in line with broader European trends identified in the key EU strategy documents on OHS: new technologies, growing use of information and communication technology, growth in the service sector, more specific risks (ergonomics and personal contact with people, stress, violence); new forms of work, such as telework, self-employment, subcontracting, temporary employment; ageing workforce; increasing interest in autonomous work; changing management structures, organizations have become flatter, smaller and leaner; a growing number of SMEs, in which health and safety knowledge and resources are often insufficient; increasing work pace and work load.

Even though rapid improvement has been made in the field of OHS in Estonia in recent years, there are still challenges ahead. The OHS infrastructure in Estonia is still poor. The effectiveness of the present OHS system in Estonia is undermined by the insufficient coverage of occupational health services, lack of political will to meet EU OHS requirements, lack of relevant statistical data and research activities in the field, poor quality of risk assessment and the continuing absence of an insurance act for occupational accidents and diseases which effectively places the burden of compensation, support and rehabilitation as a result of workplace injury or ill health on the individual worker and their family.

Further research in OHS would be helpful to have better information on occupational accidents and diseases, risk factors, good practice, and safety management systems. This would make it possible to increase the effectiveness of an OHS monitoring system to include quantitative as well as qualitative data. OHS monitoring should support knowledge-based administrative decisions on legislation, law enforcement, research and setting of priorities, monitoring changes and identifying emerging risks, as well as designing and setting up corrective and better preventive measures. There is also a need for further identification and anticipation of emerging of OHS-related risk and an evaluation of many safety measures that are in place or planned. To achieve positive results, it is necessary to strengthen the national OHS system in Estonia as well as the public's awareness through tripartite collaboration. This includes legal provisions, enforcement, compliance and labour inspection capacity and capability, knowledge management, information exchange, research and support services. Finally, the suppresion of good practice in OHS requires that representatives of the workforce be empowered in the process of OHS management at enterprise and workplace level. Here, the challenges facing Estonia are not unique, and the example of nearby Finland may reveal new avenues for employee participation in OHS. In this respect, the gulf between neighbours still remains to be crossed.

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# Appendix 2.

**Research paper II**

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# THE FORMATION OF A GOOD SAFETY CULTURE AT ENTERPRISE

## Marina Järvis[1], Piia Tint[2]

*Tallinn University of Technology, Estonia,*
*Kopli 101, 11712 Tallinn, Estonia*
*E-mails: [1]marina@staff.ttu.ee; [2]piia.tint@tv.ttu.ee*

**Abstract.** The aim of the study is to show innovative possibilities for improvement of safety culture at enterprises through complex approach to occupational health and safety (OH&S). The knowledge of the leadership and workers in OH&S is not sufficient at present in Estonia, particularly in small and medium-sized enterprises (the number is 60 000). The small (up to 50 workers) or medium-sized enterprises (up to 150 workers) have no possibility to hire the working environment specialist who would deal only with OH&S problems. Usually obligations in the field of OH&S in small and medium-sized enterprises are delegated to one employee in addition to other responsibilities related to personnel, security, fire protection and environmental problems. Therefore, the complex approach to management of OH&S issues is needed in order to create a good safety culture and to achieve positive results in company safety performance. The complex method consists of risk assessment and determination of safety level. The authors offer possible tools – simple computer applications which are available for managers, interviews with employers, employees and occupational health specialists for development and dissemination of safety culture. The opinion of workers and occupational health specialists has been taken into consideration in the planning of improvements of working conditions by the employers. The economic issues of safety and health improvement measures are presented.

**Keywords:** occupational safety and health, safety level, safety culture, risk assessment, human factors, innovative research method.

## 1. Introduction

Safety culture is a key element in the development of complex models to explain or predict safety relevant outcomes, such as safety behaviour, safety compliance or accidents, and may help explain the "human factor" in relation to organisational safety issues and performance. These processes may be studied at different levels of analyses and even at different levels of analyses simultaneously (Cheyne *et al.* 2008). Safety culture contains three interacting elements: risk controls, attitudes and behaviour, and its effective development depends on good cooperation and communications between employers, employees and Occupational Health Services (OHS). In Estonia, the services provided by an occupational health physician, an occupational health nurse, an occupational hygienist, a psychologist or a specialist of ergonomics are considered to be OHS. These service providers are all called 'occupational health specialists' (OHsp). According to the Estonian Act on Occupational Health and Safety, only entrepreneurs or private medical companies may provide the OHS.

The benefits of OHS are obvious and objectively demonstrable. Economic evaluation (cost-benefit analysis, cost-effectiveness analysis, and cost utility analysis) of such service is thus important as a guide to rational choices, the dependency on the validity of assumptions made being the main limitation, along with the non-consideration of social and ethical objectives if decisions are based on costs and benefit alone. Ultimately, the formulation of policies on OHS must be both economically and ethically sound (Meng 2005; Grozdanovic 2001).

Work-related injuries and illnesses kill an estimated 1.2 million people around the world every year. 250 million work-related accidents and 160 million work-related illnesses occur annually (Somavia 2005) and these numbers translate into an annual economic loss of approximately 4% of the world gross national product (International … 2001). Only an estimated 5-10% of the workers in developing countries and 20-50% of the workers in industrialized countries (85% in Finland, (Walters 1996) have access to adequate OHS. Relatively little information is available on the process and customers of OHS. The only indications of the

coverage and contents of OHS are obtained indirectly form the information labour inspectors gather annually from employers. In addition, only a minority (22%) of workers is covered by the OHS and has access to the occupational health physician in Estonia (Järvis and Tint 2007). Even in a developed country like the United States, approximately 70% of the 100 million workforce are not covered by OHS (Somavia 2005). The OHS have been endorsed by both the WHO and the ILO as a prescription for a healthier, happier, and more productive workforce.

Although a healthier workforce will almost certainly mean decreased absenteeism and increased workers' compensation claims, one must still weigh the benefits against the costs and seek the most cost-effective way of achieving the same results. In the estimation of the benefits, a monetary value is apportioned to the avoided consequences (for example costs of health care, rehabilitation, or workers' compensation). The analysis should also take into consideration the fact that costs and benefits may be generated over a period of time, the costs and benefits often occurring in different time periods. Because costs or benefits 10 years later are not directly comparable with their value today. The effects on productivity and reduced sickness absence can also be quantified and reflected as savings. More sophisticated forms of cost-benefit analyses would factor other intangible benefits into the equation. Providing employees with on-site primary health care may give them a sense of loyalty to the company because the company is demonstrating that it cares for its employees. The full economic losses due to accidents are not demonstrated clearly in Estonia. Data from the Health Insurance Fund (responsible for public health care in Estonia) have been publicly ac-cessible only in two recent years. However, these data (Table 1) do not contain the indirect costs of accidents and diseases (the costs for hiring the substitute labour, training for the job, the lost or degraded production quality, etc.). At present, the coverage for occupational accidents and occupational diseases are integrated into the Estonian health insurance (temporary loss of work ability) and pension insurance (permanent loss of work ability) schemes. The system of occupational disability and occupational accidents insurance is voluntary in Estonia and not effective (Järvis and Tint 2007).

Many companies have embarked on the road to establish safe working cultures in order to improve their safety performance. The so-called behaviour-based safety programs are the vehicles to achieve this desired outcome (Gadomski 2008). Indeed, some companies have experienced huge improvements in their safety performance while others, however, utterly failed (Pheiffer 2008). The behaviour-based safety program accepts that risk-taking is essential and fundamental to doing work and that no work at the workplace can ever be made risk-free. Therefore, the focus should be that employees become competent to identify and assess risks and act appropriately. This approach specifically targets the complacency factor, which is a natural result if people perceive their work environments and procedures to be safe. One of the tools in achieving safety is to focus on employees' behaviour and attitudes. In order to encourage the employees to achieve high safety standards the managers must lead by the models of the behaviour that include risk awareness tools, motivational tools and behaviour observations. Over the years companies have installed many programs and processes to prevent incidents and to control losses. According to Germain *et al.* (1998) some

**Table 1**. Number of workdays lost and expenses incurred due to occupational accidents (Ministry … 2006)

|  | 1995 | 2000 | 2002 | 2003 | 2004 | 2006 |
|---|---|---|---|---|---|---|
| Number of workdays lost due to the occupational accidents | 83 643 | 157 051 | 171 850 | 146 411 | 118 941 | 125 314 |
| Percentage of workdays lost due to occupational accidents in the total number of sick-leave days | ….. | 3.1 | 3.7 | 3.1 | 3.7 | 2.3 |
| Occupational accident benefit, million EEK/ million EURO | 6.3/0.4 | 19.5/1.23 | 25.2/1.6 | 23.1/1.47 | 20.4/1.3 | 22.9/1.46 |
| Number of certificates of incapacity for work | 2783 | 6921 | 7572 | 6871 | 5863 | 5996 |
| Compensation for damages related to occupational accidents and diseases, million EEK/million EURO | …. | 21.6/1.38 | 34.6/2.2 | 36.9/2.35 | 38.3/2.44 | 36.0/2.20 |
| Number of people receiving compensation for damages | …. | 1111 | 1553 | 1646 | 1745 | 2216 |

companies believe that the best way to achieve incident control is through additional regulations, focusing on prescriptive and technological approach, there is also a merging willingness by people in industry and business to try a new and complementary approach. This approach is then effective safety management through good management systems. It is clear that there is a direct link between good safety management systems and good business management (Wallace 1995). Organisations with high safety standards are those with high operational standards because the management actions necessary to achieve safety are the same which are required to achieve business efficiency. Over time various safety approaches were indeed developed and implemented by companies to assist them in the managing of safety and include engineering design, legal approach, safety systems, risk management and more recently behaviour-based safety. The aim is to change employees' perception and attitudes (at all levels) towards safety behaviour, so that they understand the role and impact of their own behaviours on safety. The way, in which employees understand risks, their attitudes towards safety and taking the responsibility of safety of the person himself and the others are important factors in good safety culture. There are three major factors which influence employee behaviour: the company safety culture, which should promote involvement and commitment to the company goals and standards; the job itself; the strengths and weaknesses of the employee, which include habits, attitudes, personality and current stresses (Wallace 1995). New demands from the companies' environment entail that work safety becomes strategically more important for management (Järvis and Tint 2007; Reinhold and Tint 2007). The safety management system consists of the

following elements (thematic areas): management and leadership, training of management and personnel, operations, maintenance, risk assessment, emergency planning, monitoring of performance and audit (Machaira *et al.* 2008).

## 2. Material and methods

1) Management of hazards at workplace- following Fig. 1; 2) A simple risk assessment method (Reinhold *et al.* 2006), described on p. 4; 3) For the determination of safety level at the six enterprises, the modified Diekemper & Spartz method (Kuusisto 2000) was used, also described on p. 5; 4) The questioning of managers about their activities and willingness to carry out improvements in the field of OH&S (p. 7); 5) The questioning of workers for taking into consideration their opinion in working out plans for positive changes in the working environment (p. 6); 6) The questioning of occupational health specialists (doctors and nurses) for clearing-up the possibilities to increase their role in improvement of safety culture at enterprises (p. 9).

The investigated enterprises were from manufacturing: printing, mechanical, plastics, wood processing, textile industry and the water purification plant (Cases I-VI).

## 3. Risk assessment at the workplace based on a simple risk assessment method

A computerized version of the simple/flexible risk assessment method (Reinhold *et al.* 2006) is shown in Fig. 2. The method gives four risk levels (negligible, justified, inadmissible, intolerable risk) and enables to show graphically the level of risk according to the measurements in the work environment (Table 2).
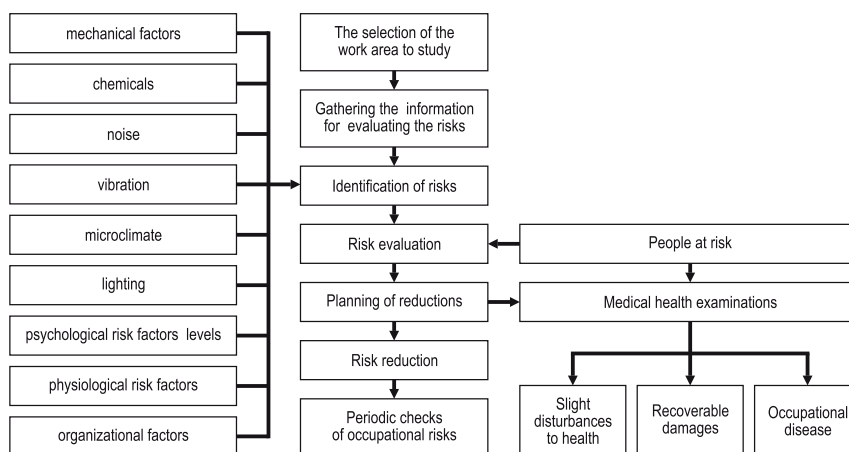


**Fig. 1.** The management of hazards at workplace
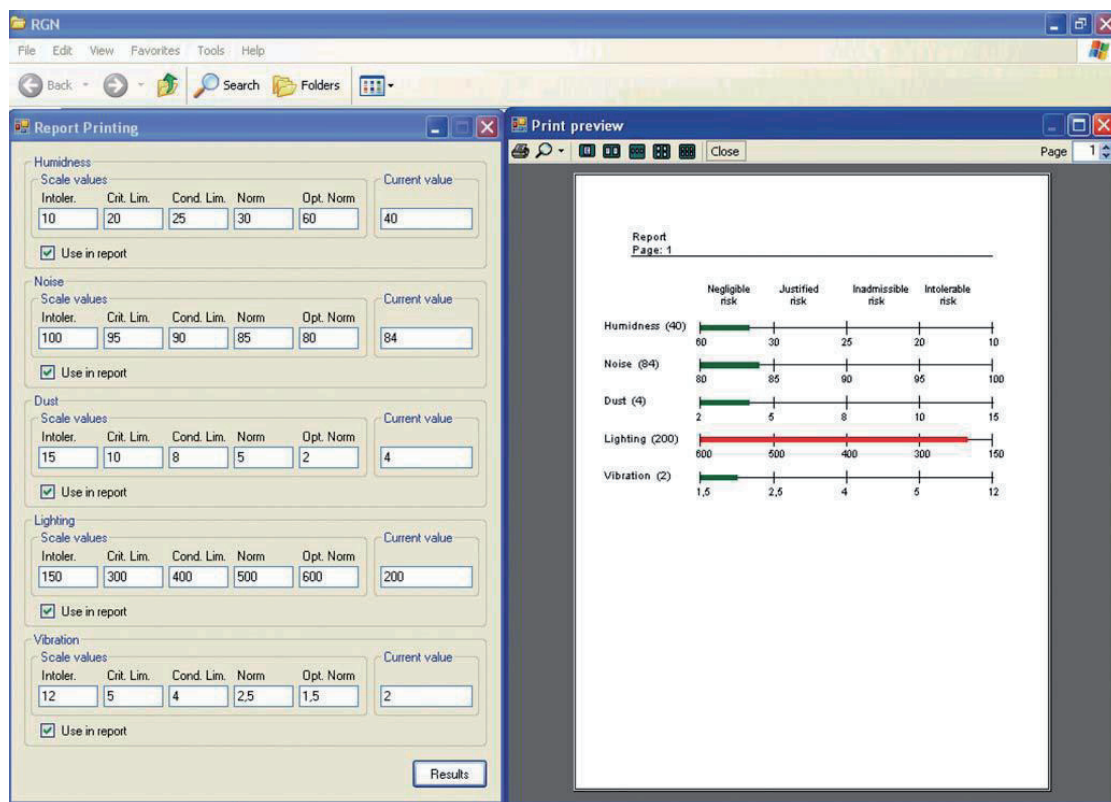
**Fig. 2**. The computerized method for risk assessment at workplace

**Table 2.** Overall results of measurements of working conditions in manufacturing (Reinhold and Tint 2008

| Industry | Indoor air temperature, °C, U = 0.6 °C | | Indoor air humidity, %, U = 2.0% | | Dust, mg/m³ U = 0.3 mg/m³ | Lighting, lx, U = 10.4% | Noise level, dB(A), U = 2.0 dB |
|---|---|---|---|---|---|---|---|
| | Cold season | Warm season | Cold season | Warm season | | General lighting | |
| Case I (printing) | 21.7..22.4 | 22.5...24.3 | 38.2...52.2 | 44.2...62.4 | 0.7…2.5 | 264…1625 | 66.4…90.3 |
| Case II (mechanical) | 10.8..21.4 | 17.6...23.2 | 31.3…39.9 | 41.4…48.7 | 2.0…10.0 | 88…1256 | 73.0…97.5 |
| Case III (plastic) | 14.0..22.4 | 18.6...25.5 | 26.1…40.7 | 36.5…45.7 | 0.4... 1.0 | 138…742 | 61.1…83.8 |
| Case IV (wood) | 21.2..24.0 | 24.3...26.5 | 34.2…42.6 | 35.1…47.6 | 2.05…6.0 | 320…1050 | 84.2…94.4 |
| Case V (textile) | 20.3..23.5 | 22.7...25.6 | 44.4…53.0 | 48.2…53.0 | 1.2..... .4.4 | 525…2040 | 62.1…89.5 |
| Case VI (water purification) | 14.0..23.0 | 17.0...26.7 | 32.6…47.9 | 39.5…54.6 | not measured | 200....500 | 67.6....82.4 |

For example, lighting 200 lx in wood processing industry is inadmissible risk for work with saws and other tools and equipment for cutting wooden raw material and also in furniture industry (400–500 needed). Noise level 84 dB(A) is acceptable risk if earmuffs are used (85 dB(A) – the exposure limit for 8-hours workday). Dust 4 mg/m$^3$ is acceptable risk as the limit is 5 mg/m$^3$ for inhalable dust and 10 mg/m$^3$ for overall dust (2 mg/m$^3$ for pure wood dust).

## 4. Safety management at the enterprise

Safety audits are a vital way of verifying that company's safety management is working properly. Several methods have been developed for supporting safety auditing: questionnaires, interviews, observations and document reviews. Safety management system in 6 Estonian enterprises were assessed using Diekemper & Spartz (D&S) method, which was modified by Kuusisto considering the demands of the OH&S standard OHSAS 18001 (Diekemper and Spartz 1970). The investigated enterprises were selected from the manufacturing industries (Cases 1-VI).

The assessment in this method is carried out on four level systems: level 1(poor); level 2 (fair); level 3 (good); level 4 (excellent) (example Table 3A).

The modified D&S method addresses 30 activities. These are categorized into the following activity areas:

**A\*** – organization and administration (statement of policy, responsibilities assigned; direct management involvement; safety instructions to hazardous tasks; workplace design; health care)

**B\*** – industrial hazard control (housekeeping-storage of materials; machine guarding; maintenance of equipment, guards, hand tools; material handling- manual and automated; and personal protective equipment)

**C\*** – fire control and industrial hygiene (chemical hazard control references; storage of flammable and explosive materials; ventilation- fumes, smoke and dust control; skin contamination control; fire control measures)

**D\*** – supervisory participation, motivation and training, line supervisor safety training; training of new employees; job hazard analysis; training for specialized operations (fork trucks, grinding, punch presses, solvent handling, etc.); worker/manager safety contact and communication)

**E\*** – accident investigation, statistics and reporting procedures, accident investigation by line personnel; accident cause analysis and statistics; near-accident investigation).

**Case I** (printing industry) was carried out at the enterprise with 162 employees. The factory has invested in a great deal to improve the status of premises. The manufacturing process operated in three shifts. The premises were new. The company had no safety manager; the duties were delegated to the personnel manager, who had the responsibility to deal not only with OH&S issues but also environmental and security management systems. The main types of accidents occurred in the company were slips, pinching of fingers and back injuries. The company's employees were rather experienced (half of them worked in the factory for 10–20 years).

The highest scores were given to part B – industrial hazard control (15: workers were equipped with personal protective equipment, good storage of materials, material handling – manual and automated etc.), the lowest one (10) was given to part E (accident investigation). The E part was assessed low for all investigated companies (except Case VI) as the near-accident investigation was not performed in any of the companies (except Case VI). Part D obtained the score 11: safety training was carried out on a regular basis, but no written guidelines or programme for internal audits were presented. In most cases, new employees were trained by senior workers.

**Table 3A.** Modified Diekemper & Spartz method for assessment of safety system.
Determination activities' safety level (area A)

A. Organization and administration

| Activity | LEVEL I (Poor) | LEVEL 2 (Fair) | LEVEL 3 (Good) | LEVEL 4 (Excellent) |
|---|---|---|---|---|
| 1.Statement of policy, responsibilities assigned | No statement of safety policy. Responsibility and accountability not assigned | A general understanding of safety, responsibilities and accountability, but not in written form | Safety policy responsibilities written and distributed to supervisors | In addition to previous items, safety policy is reviewed annually. Responsibility and accountability is emphasized in supervisory performance evaluations |

**Case II** (mechanical industry) was carried out in a mechanical factory producing two-wheeled trailers for passenger cars. The number of workers is 136. The company is located in 3 different places: the sale department is situated in Tallinn and the manufacturing buildings about 25 km from the capital. The welding process (6 workplaces) was carried out in unsafe working conditions (in the building made of silica brick, without any ventilation). However, the number of occupational accidents showed a decreasing trend. The workers were complaining on back injuries caused by lifting tasks. These injuries were typically caused by sharp pieces of sheet metal. The interest from the side of management was obvious. The highest scores (10) were given to the parts A to C. The lowest score (8.3) was obtained for part E: neither accident statistics nor near-accident investigation took place in the company. Vast attempts were taken by the management to improve the ventilation in welding activities, but some rearrangements are still possible for cleaning the air in the breathing zone of workers. The respirators were used during the welding work.

**Case III** (plastic industry) was carried out in the firm on Saaremaa island (located in the west of Estonia), which is producing rubber products for car industry situated outside of Estonia (Germany). The number of employees is 160. The quality control of these products (package rings included) needs very good eye-sight from workers. Therefore, only the girls at the age of 18–25 years old not wearing glasses were hired to perform this work. The plastic firm only planned to send the workers to the medical health examination after the reviewing of the risk assessments results. The highest score (12) in safety performance was obtained in part B (housekeeping, machine guarding, etc.) because almost all machines were new, premises good as the factory itself was only 2 years old. The lowest score (9) was obtained in part A, because there was absence

of safety policy and instructions as well as a lack of worker's health examinations.

**Cases IV** (wood processing industry) was performed in the enterprise with approximately 300 workers, which is located in a small town in the west of Estonia. This company produced furniture and used different volatile chemicals in lacquering process. The main occupational hazard was dust ($5-10$ mg/m$^3$ in the air of the working environment). The safety training seemed to be performed and good, because ear muffs and plugs were used properly and most of the workers were aware of health risks. The safety manager has long-working experience.

**Case V (**textile industry, 400 employees, situated in Tallinn). The accidents were investigated in depth and relative corrective measures were effectively implemented. In textile industry, the workers were not keen on wearing the ear plugs (all other personal protective equipment was used correctly). The safety manager has good safety training and therefore was able to carry out risk assessments at workplaces herself.

**Case VI** was performed in water purification plant in Tallinn (320 workers) which has an international occupational health and safety management system specification (OHSAS 18000). Nearly all of the parts of the audit (from A to E) were assessed as level "4" – excellent; only in part D there were some shortcomings (absence of written program outlining internal inspection guidelines, responsibilities, frequency and follow up). The results of the implementation of the D&S method for external safety audit are given in Table 3B and a computerized method for determination of safety level is presented in Fig. 3.

The investigation of safety level had the positive results in every company. The workers and the management of the companies had the possibility to perceive the problems that were essential parts of the working

**Table 3B.** Results of auditing of safety system in Estonian enterprises

| Industry | A* | B* | C* | D* | E* | Total score |
|---|---|---|---|---|---|---|
| Case I (printing industry) | 13 | 15 | 11 | 11 | 10 | 60 |
| Case II (mechanical industry) | 10 | 10 | 10 | 9 | 8.3 | 47.3 |
| Case III (plastics industry) | 9 | 12 | 10 | 11 | 11.6 | 53.6 |
| Case IV (wood processing industry) | 8 | 10 | 10 | 11 | 11.6 | 50.6 |
| Case V (textile industry) | 13 | 15 | 10 | 9 | 10 | 57 |
| Case VI (water purification plant), OHSAS 18001 implemented | 18 | 18 | 19 | 15 | 15 | 85 |

*Maximum score in each area (A, B, C, D, E) is 20. Maximum total score is 100.

**Fig**. 3. A simple computerized method for determination of safety level at enterprise

environment before (noise, draught, etc.). The managers were satisfied with the database on legislation, proposed new methods for advanced learning in the field of OH&S and computerized method for risk assessment. The greatest problems in the implementation of the model came up in the communication between the worker and co-worker, and the worker and the first level foremen. Therefore a guide was elaborated for co-workers safety behaviour. The interviews with employers were carried out in the same enterprises where the safety level was assessed.

The original D&S method is a rough method, and it does not help the auditor to assess the individual safety activities very thoroughly and demands the high expertise of the auditor. The D&S method also suggests certain activities which may not always be the most suitable and relevant solutions for every company.

## 5. The worker's opinion about working conditions

The data were collected during 2002–2004. The objective of the questionnaire was to gather information about the workers' knowledge of the occupational risks connected with their occupation, possible work-related occupational hazards, and attitudes towards using personal protective equipment and safety routines. Questions about the workers' opinions and their perceptions about the exposure to occupational risks (noise, chemicals, vibration, bad microclimate, insufficient lighting, and ergonomics), experienced health symptoms and their awareness of the Occupational Health and Safety Act were also asked. The workers were randomly selected from textile, printing, mechanical, plastic, food processing industries and offices. A questionnaire was distributed to 412 workers in investigated industries. The average age was 43.6 years. Confidentiality of information was always maintained and only coded information was used in the analysis. Data collected on the questionnaire study was coded and then entered into the statistical software programme (Excel) for analyses. The investigation gave results as follows:

1. 65% of workers considered excessive exposure to noise, 60% bad microclimate (too cold workrooms), 54% bad lighting at workplaces; not-effective ventilation was the main occupational risk factor (75% of workplaces).

2. Only some of the workers (10%) answered that they know which information about the dangerousness of chemicals may be obtained from the chemical labels. Nobody of respondents pointed at the chemical safety data sheets as one of the important source of information.

3. Most of the workers (80%) reported that personal protective equipment (PPE) was accessible; however, the questionnaire did not show the attitudes towards using PPE. Some of the respondents (36%) pointed that the PPE disturbs the work; others mentioned (46%) that the quality of PPE is not very good.

4. In the present study, 63% of the workers reported that they were aware of the person who was the working environment specialist in their company. At the same time, only 20% of workers knew who was elected to be their working environment representative.

5. Different opinions were given on safety instructions and guidelines. In the present study, 25% of the workers reported that they had not received safety instructions and guidelines. The assessment of the safety instructions was made on a 6-point scale (from 0 to 5, where 0 was bad and 5 – very good). According to workers' opinion, the quality of accessed safety instruction was satisfactory (2.8 points).

6. The questionnaire revealed that only 25% were generally aware of the safety legislation.

The investigation of the workers' knowledge on the legislation in the field of OH&S was carried out by the authors also in September 2008 in four enterprises. The 422 questionnaires were received from different

branches of industry: 162 from the textile industry; 25 from the wood processing industry; 200 from the mechanical industry and 35 from the printing industry. The average age of the workers (N = 422) was 45 years. The results show that the workers are aware of their rights and responsibilities decreed by the OH&S regulations. Even, if workers know who their working environment representative is, in the case of shortages in the working environment, they prefer to turn to the direct foreman at their workplace, not to their working environment representative. The workers considered the insufficient lighting (82%), dust (34%), noise (75%) and vibration (45%) to be the main occupational risk factors in their workplaces.

In addition, half of the correspondents (50%) stated that they have to work in a stationary position.

On the basis of the investigation it could be concluded that the questionnaire for workers has to be rather short (10 questions, including list of hazards in the working environment and the scale has to be not more that 4 (from 1 as bad to 4 as very good working conditions). **The questionnaire for workers** has to include the following questions:

1. Do you know your working environment representative?
2. What kind of the following hazards disturbs you in the working environment: noise, vibration, insufficient or too strong lighting, cold or hot microclimate, too dry air, smell of chemicals, dust and how strongly? Do you lift heavy loads or work in the compulsory position?
3. What do you do with your co-workers and foreman? To whom do you approach with non-compliance in the working environment?
4. Are you supplied with the Chemical Data Sheets (CDS)? What information do you get from CDS? What are R- and S-phrases?
5. Have you the instructions for safe work methods in written form at your workplace?
6. Are you supplied with personal protective equipment (PPE)? Are these comfortable or does the PPE disturb your work? Do you wear PPE always when it is needed by the instructions?

## 6. The awareness of employers on OH&S matters in investigated companies

Semi-structured interviews with top management were carried out in 6 enterprises in order to gather information about their awareness in the field of OH&S. The management of 80% of the investigated companies (Cases I-VI) considered the role of working environ-

ment as an important. 30% of the interviewed companies had a certain plan of activities to improve working conditions, 15% of companies were composing the plan how to reduce the occupational risks. Psychological risk factors (also forced position, monotonous work) received the most negative assessment from different sides of working environment. It is understandable as the factor appears in the case of all fields of activities and different size of companies, when at the same time, for example, physical load of the job or its dangerousness appears only in the case of some field of activities or occupations (printing, wood processing). Attitudes to working conditions, design/furniture of the workplace and work related daily living conditions received less negative assessments. Respondents were asked also to evaluate on a 10-point scale their employees' risk to impair their health at work. Two thirds of respondents consider the risk to their employees' health sufficiently low (1–4 points). 15% of interviewed companies did not see any risk factors that would endanger employees' health. Industry managers mentioned as the main risk factors to the employees' health are noise (80%), vibration (70%), physical overload (50%), fluctuation of temperature (50%) and work monotonousness (50%). Despite the fact that companies from different field of activities evaluate risk factors to employees' health differently, there are no significant differences in assessment of employees' sickness problems. Occupational diseases and the other health problems were bothering factors only for some (30%) of the companies. In order to assess the persons, who follow the situation of the working environment, companies' management was asked about the existence of different specialists like working environment representative or council in their companies. Only in a half of the companies the working environment representative was elected and working environment specialists were working in 30% of companies. Looking at the evaluations of different persons' efficiency to the improvement of working environment, we can see that only some companies, where separately relevant persons exist, estimate their work as very efficient and half up to 2/3 of interviewed companies as sufficient. Therefore, the relevant specialists have not found sufficient employment in their positions. In addition to specialists who work inside the company, there is a possibility to include the agreement for carrying out the working environment investigations externally. 100% of investigated companies (Cases I-VI) used the last possibility. The external specialist's help has been mainly used for conducting workplace risk assessment (including hazards' measurements) and consulting companies in the field of OH&S.

## 7. The assessment of economic losses connected with lack of safety performance

The most deep working environment survey including economic side of OHS in Estonian enterprises and firms was carried out by TNS Emor in March 2000 (Working ... 2000). TNS Emor is the largest full service marketing research and consulting company in Estonia. One of the parts of the survey also concluded the employers' survey (402 successful interviews).

Only 8% of companies had tried to evaluate the economic loss that had been caused by the employees' sicknesses. Bigger companies, with more than 150 employees, have done it more frequently than the average (19%), but 67% of all those who have tried to evaluate that, were not able to give the concrete amount of money spent in 2000. That is why it was also impossible to estimate companies' economic loss, caused by employees' sicknesses. Nine companies estimated the economic losses caused by employees sicknesses of approximately 39 000 EEK (1 EUR = 15.6 EEK) per one year. In addition to the abovementioned sicknesses, also work-related accidents during the last three years were observed in the survey. In total, in 12% of companies, that operate in Estonia work-related accidents had taken place. More frequently than the average the accidents had appeared in industrial, construction and transportation companies.

The overview of different types of expenditures made by companies on their employees and the working environment: on average, each company had made different types of expenditures during 2000: 4.2 times. The majority of companies had made expenditures on improvement of working and work-related daily living conditions and purchase of working clothes and PPE. The expenditures, made during 2000 by companies that operate in Estonia, on improvement of working environment in total amount estimation together with probability limits. The highest expenditures were related to improvement of working conditions: between 1.13–3.06 billion EEK (p<0.05), it was followed by the expenditures on improvement of work-related daily living conditions – between 0.49–0.72 billion EEK and on working clothes and personal protection equipment – 0.22–0.4 billion EEK. The expenditures made by companies in connection with employees' health: the biggest amounts had been spent on employees' sporting possibilities: 113–215 million EEK (p<0.05), it was followed by almost the same level expenditures on health control, occupational health and safety training and making of health insurance contracts. In total, the expenditures made by the companies on improve-

ment of working environment per one year were between 3.45–4.47 billion EEK (p<0.05). Depending on the type of expenditures, they apply to 15–81% of companies. Of those companies, who had not made any certain type of expenditures on working environment or employees' health-related factors during 2000, were asked how necessary would they evaluate that the employer makes such kind of expenditures. Three-quarter of companies, who did not make expenditures on improvement of working and work-related daily living conditions during the previous year, considered the expenditures necessary. Also, explanation of occupational safety questions to employees was evaluated as very necessary.

The respondents were also asked to name concrete factors that need to be improved in their company's working environment. 44% of respondents brought out different factors. The abovementioned improvements presume relatively big investments. Respondents gave sums between 2000 EEK and up to 20-30 million EEK. The last one means practically constructing a new building. Considering partially very approximately given assessments by respondents and also the fact that 67% of all interviewed companies were not able to name a certain number that they would spend on making changes in the working environment, it is not correct to extend the results in order to find out the investment needs of all companies that operate in Estonia.

As a result of the investigation the proposal for self-assessment questionnaire for employers is presented:
1. How much do your company's working conditions correspond to the requirements set by the law of occupational health and safety?
2. Have you composed the plan of activities to improve the working conditions in your company/institution?
3. How much do you take into consideration the proposals that employees make for improving the working conditions?
4. Has the National Labour Inspectorate inspected your company/institution? What were the results of the inspecting?
5. Please give your assessments on a 10-point scale, how big is your employees' risk to impair their health at work?
6. Which of the following hazards in the working environment (dust, noise, vibration, bad lighting, lack of ventilation, temperature, dangerous chemicals, forced position, monotonous work, physical load, mental stress) do you estimate as risk factors to your employees' health?

7. How much do the employees' illnesses bother your company's/institution's activities?

8. Have you evaluated economic loss caused by employees' sicknesses – lost working time, undone work?

9. Have you spent money during the previous year on employees' vaccination, employees' health control, offering sporting opportunities to employees, making insurance contracts to employees on company's/institution's initiative, working environment specialist and representative training and advance training, first-aid training, measuring the working environment risk factors, improving working conditions, improving work-related daily living conditions, working clothes and personal protection equipment?

10. Does a working environment specialist – work in your company/institution, has the working environment representative been chosen among the employees, does the working environment council operate?

11. Have you included Occupational Health Service or an occupational health specialist (medical doctor, nurse) into the working condition analyses?

## 8. Survey of occupational health and safety professionals in Estonia

As part of the Estonian-Finnish Twinning Project on Occupational Health it was decided to carry out a survey of occupational health and safety practices and development needs in Estonia. The aim of the survey was to get knowledge of the current practices, main priorities and major problems, attitudes, professional skills and perceived needs for further education among OH&S professionals. The study was carried out using a questionnaire designed for the occupational health and safety professionals. The target group for the survey were all the 103 OH&S professionals (occupational health physicians (OH physicians), OH nurses, hygienists, ergonomists, psychologists) who were practising as occupational health and safety professionals at the time of the data collection in Estonia (Kempinen and Sarap 2002). Although the response rate was low, 40%, the size of the study group was large enough to assess the major problems in the field of occupational health and safety and to describe the occupational health and safety professionals' attitudes, level of education and knowledge. However, statistical analysis for the differences between the groups could not be done. The work experience in the field of OH&S of the participants in the survey varied between the professional

groups. OH physicians had longer work experience (the average 21.4 years) than other specialists. 60% of OH physicians and 80% of nurses worked in health care centres where they performed OHS besides other medical services. The main tasks of OH&S professionals consisted of risk assessments, workplace surveys, health examinations, advice related to work, but also health promotion activities. Most of the respondents were experienced professionals, with high level of training. The professionals stated that occupational diseases and work-elated diseases (diagnostic and prevention), rehabilitation and/or promotion of work ability were the main subjects for need in further training. Also, a need for clarifying guidelines of Occupational Health and Safety, legislation and regulations in Estonia was identified. 90% of OH physicians stated that they can understand Estonian, 42% of OH physicians can speak Russian; 27% can speak English and most of the physicians reported that they understand Finnish language. Access to Internet was available for 82 % of the respondents, and most of them used it for information search, on average 5 hours/week. All of the occupational health physicians and nurses answered that workers told them about work-related health problems at least weekly. Two thirds of the respondents considered, that the workers were not afraid of telling about these problems to them (Kempinen and Sarap 2002). According to OH&S professionals' responses, there are the following main priorities and major problems in the OH&S practice in Estonia:

1. The absence of Insurance Act of Occupational Accidents and Diseases.

2. The absence of the Governmental participation in the field of occupational health and safety (Governmental financial support).

3. It is impossible to analyse sensitive personal data.

4. The absence of an agreement between OH physicians and Health Insurance Fund in order to provide financial support for the rehabilitation services.

5. There is a lack of OHS in Estonia (low coverage of the OHS services offered to employees).

6. There is insufficient work collaboration between Occupational Health and Safety Institutions in Estonia.

7. Lack of knowledge among employers and workers concerning the Estonian National Policy on the working environment and their awareness of OH&S is insufficient.

8. Lack of the OH&S professionals and of the research activities in Estonia (Kempinen and Sarap 2002).

## 9. Discussion and Conclusions

As the conclusion of the investigation, the following scheme can been drawn for the improvement of safety culture at the enterprise (Fig. 4). The most important issue at companies is the collective awareness of safety learning necessity (Kumpikaitė 2008; Kumpikaitė and Čiarnienė 2008). Instructions and rules are the key ways of achieving a healthy working environment and risk control. There is a concentration on observable action, both human and social. The machinery or the rules may not be flexible when changes in production are required. It is likely that production would come out victorious in any such conflict. The occupational disease develops by stages (Fig. 1): some complaints, recoverable disease, non-recoverable disease. The co-operation between the employer, worker and occupational health physicians is urgent in order to achieve the positive safety culture and high safety performance at the enterprise. At present, most of the occupational diseases are diagnosed at the very last stage in Estonia. The diagnoses of occupational diseases as well as maintenance of work ability are still in the need for development in Estonian OH&S system.

The knowledge about safety and health is very different in different companies. Some of the managers are competent, but the workers' knowledge of OH&S is low because they do not receive proper safety training and there is a lack of guidelines. Only workers involved in very dangerous operations are instructed and trained regularly.

Further research is needed in order to understand the factors involved in safety culture and safety management system at the enterprise, how OH&S knowledge is disseminated and translated into practice, especially focusing on knowledge management for young workers, non-Estonian speaking, for employers and employees in small business. There is also a need for strengthening of national OH&S system in Estonia as well as awareness of the public through tripartite collaboration, and this includes legal provisions, enforcement, compliance and labour inspection capacity and capability, knowledge management strategy, information exchange, research and support services.

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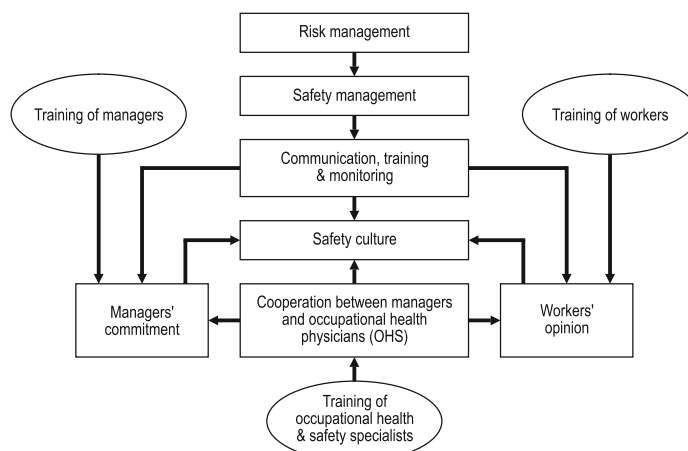International Labour Organization (ILO). 2001. *Guidelines on occupational safety and health management systems.*

**Fig. 4.** The influence of different parties on OH&S at workplaces

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**Appendix 3.**

**Research paper III**

Tint, P., Järvis, M., Reinhold, K., Paas, Õ. (2009) Risk Assessment and Measurement of Hazards in Estonian Enterprises. *Environmental Engineering and Management Journal*. Volume 8, No 5: 1165-1170. (ETIS 1.1)

***"Gheorghe Asachi" Technical University of Iasi, Romania***

# Environmental Integrated Management and Policy Making

# RISK ASSESSMENT AND MEASUREMENT OF HAZARDS IN ESTONIAN ENTERPRISES

## Piia Tint[∗], Marina Järvis, Karin Reinhold, Õnnela Paas

*Department of Work Environment and Safety, Tallinn University of Technology, 19086 Tallinn, Estonia*

**Abstract**

The paper focuses on occupational hazards and the determination of risk levels. Indoor climate, lighting, noise, chemicals and dust are examined. A simple/flexible risk assessment method is provided. The results of measurements of occupational hazards in six industries (mechanical, printing, wood, plastic, clothing and water purification plants) in Estonia are presented. The overall purpose of the paper is to draw the attention to the importance of measurements of occupational hazards in industry and to act as a reminder of number of issues of practical relevance to effective workplace risk assessment from which employees, employers, occupational hygienists and physicians as well as authorities can benefit.

*Key words:* measurement of hazards, occupational hazards, risk assessment

## 1. Introduction and theoretical basis

Risk assessment in the work environment has been a topic for the Estonian occupational health and safety (OHS) researchers since 1996 when the EU's "Guidance of risk assessment at work" became accessible. The Act on Occupational Health and Safety that requires risk assessment to be carried out at every workplace was adopted in Estonia in 1999 (DGV, 1996; OHSAF, 1999).

The existing risk assessment models (on the basis of BS 8800) contain the need to determine the probability of occurrence and the severity of the consequences of the impact of hazardous factors on worker. Some of the versions of risk assessment from BS 8800 (BSI, 1996; BSI, 2004), where the probabilities are given more clearly for the user, are provided by Pekkarinen (2007), Rantanen (2001); the determination of acceptable risk is given by Vasilescu et al. (2008). The model that could be used in the case of accidents is presented in the Table 1.

The chemical exposure limits in Estonia (Resolution, 2007) are determined by two different values: 8 hours' mean concentration in the air of the work environment and short term exposure limit (15 minutes). In addition, the norms also identify three levels of hazardousness of the chemical: harmful, toxic, very toxic.

Table 2 contains two factors: probability (likelihood) of the occurrence and consequences of the harm when a particular hazard is identified. The percentage of exposure limit (<10%, 10-50%, 50-100%) is presented as the probability. Exposure limits are usually expressed as time-weighted, whole-shift concentrations and where necessary, short-term peak concentrations. But in many cases exposure time to the chemical has to be considered at low concentrations, not exceeding the limits.

The determination of the probabilities is complicated for the employer (in Estonia risk assessment could be carried out by the employer himself or by the person or office recognized by the Health Care Board). From 2004, a new version of BS8800 is available that is yet more complicated than the first one (from 1999) (EVS, 2004).

Therefore the Estonian employers, particularly from small and medium-sized enterprises (the number over 50,000) where looking for a simple, flexible risk assessment method that would take into consideration the work environment hazards in a small firm. A method for risk assessment that the employers themselves could use, was needed.

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[∗] Author to whom all correspondence should be addressed: e-mail: piia.tint@tseba.ttu.ee; Phone: +372-620-3960; Fax: +372-620-3953

**Table 1.** Criteria for the likelihood and consequences of an occupational accident (Pekkarinen, 2007)

| Consequences/ Likelihood of dangerous situations | Slightly harmful Absence less than 3 days, temporary, slight consequences, sprains, bruises | Harmful Absence 3-30 days, long, serious consequences, lasting harm, fractures, burns | Extremely harmful Absence more than 30 days, permanent disability, death |
|---|---|---|---|
| **Highly unlikely** Dangerous situations occasional, appears seldom | **1. Trivial risk** No actions needed | **2. Tolerable risk** Monitoring | **3. Moderate risk** Risk control needed |
| **Unlikely** Dangerous situations almost daily, near misses have occurred | **2. Tolerable risk** Monitoring | **3. Moderate risk** Risk control needed | **4. Substantial risk** Urgent actions |
| **Likely** Dangerous situations often and regularly, accidents have occurred | **3. Moderate risk** Risk control needed | **4. Substantial risk** Urgent actions | **5. Intolerable risk** Immediate actions |

**Table 2.** Determination of risk level in the case of hazardous chemicals in the air of work environment (Rantanen, 2001; Reinhold et al., 2009b)

| Consequences ⟶ Probability ↓ | Slightly harmful uncomfortable, irritable feeling, overcoming illnesses R20, 21, 36, 37, 38 | Harmful burning, skin diseases, long-lasting severe damages, stable slight disturbances R23, 24, 25, 33, 34, 40, 43, 48, 62, 63, 64 | Extremely harmful poisonings, occupational cancer, asthma, stable severe damages, illnesses dangerous to health R26, 27, 35, 39, 41, 42, 45, 49, 60,61, 65 |
|---|---|---|---|
| **Highly unlikely** severe damage from <10% of the limits (ELV[1]), other 10–50% of the limits | **trivial risk** no risk reduction measures needed | **tolerable risk** follow-up of risks | **moderate risk** risk reduction measures needed |
| **Unlikely** severe damage from 10–50% of the limits, other 50–100% of the limits | **tolerable risk** follow-up of risks | **moderate risk** risk reduction measures needed | **substantial risk** risk reduction measures inevitable |
| **Likely** severe damage from 50-100% of the limits, other over limits | **moderate risk** risk reduction measures needed | **substantial risk** risk reduction measures inevitable | **intolerable risk** risk reduction measures to be implemented at once |

[1]ELV – Exposure limit value

A simple/flexible risk assessment method was worked out in Tallinn University of Technology (Tint and Kiivet, 2003). It is based on a two-step model that can be enlarged.

In the case of the assessment of the magnitude of risk a simple (flexible) risk assessment scheme is presented (Fig. 1).
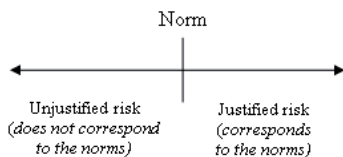


**Fig. 1.** Two-step model

The two-step model is an attempt to provide a clear, understandable schema which is simple for the user. The model has one boundary line, which is a stable, largely spread number such as an exposure limit (norm in the Fig. 1). The no/yes principle is used or corresponds to the norms/does not correspond to the norms or justified/unjustified risk. The model suits small enterprises and that do not have a complicated combination of hazards or may have inexperienced personnel in work safety assessment.

The model can be enlarged into a six-step model (Fig. 2), where the boundary line is a dotted double line that fixes zero-risk or negligible risk. In fact, we can speak of zero risk only when no hazards exist in the work environment.

The flexible model presented offers every enterprise an opportunity to choose a suitable and feasible scheme for implementation into practice.
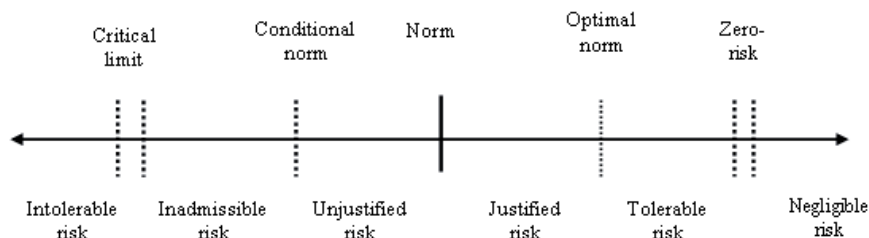
**Fig. 2.** Six-step model

**Table 3.** Summary of the investigated companies

| Industry | Number of investigated companies | Number of workers in the company | Main health hazards measured | Awareness of company safety management |
|---|---|---|---|---|
| Textile and clothing | 5 | 120…225 | Indoor climate, lighting, noise, textile dust | + (4 cases) ± (1 case) |
| Printing | 3 | 24…140 | Indoor climate, lighting, noise, paper dust, isopropanol | + (2 cases) – (1 case) |
| Wood processing | 5 | 25…200 | Indoor climate, lighting, noise, wood dust, chemicals | + (2 cases); ± (2 cases) – (1 case) |
| Mechanical | 2 | 90…175 | Indoor climate, lighting, noise, welding dust, $O_3$, CO, $CO_2$, NO-$NO_2$, HF | ± (2 cases) |
| Plastic | 3 | 25…180 | Indoor climate, lighting, noise, general dust, HF | + (1 case); ± (2 cases) |
| Water purification | 1 | 160 | Indoor climate, lighting, noise | + (1 case) |
| Office rooms | 18 | 15…100 | Indoor climate, lighting, noise, formaldehyde | + (9 cases) ± (7 cases) – (2 cases) |

(Abbreviations: "+" - stimulating, supportive; "–" - impeding, negative; "±" - neutral)

## 2. The investigated companies

The examined enterprises were selected considering the most common and obvious occupational hazards present in the industrial sector in Estonia (Table 3). Microclimate, noise and lighting were measured in all industries. Chemicals were selected from those present in the examined industries (formaldehyde (R23/24/25, R34, R40, R43) in the textile and the wood processing industries, toluene (R11, R38, R48/20; R63; R65, R67), xylene (R10, R20/21; R38), butanol (R10-22-37/38-41-67), styrene (R10, R36), benzene (R11, R45, R48/23/24/25), isocyanides (R20/22) in the wood processing industry, hydrogen fluoride (R26, R27, R28, R35, R41) in the plastic industry, isopropanol (R11, 36, 67) in the printing industry, welding gases in the mechanical industry). All the chemicals are characterized with risk phrases (Identification, 1998). Dust was measured in all types of manufacturing industries.

In each company, the management attitude towards health and safety was assessed on the basis of the interest in the results of the research, the supportive actions to provide adequate information

and details about the company and its investments into health and safety and the appreciation of workers' health through available protection, benefits, technical and administrative solutions present in the company and further efforts to enhance workplace safety. The awareness and supportive actions of the company management concerning occupational health and safety were assessed as stimulating/supportive, neutral or impeding/negative.

## 3. Results of the measurements in the work environment

To perform the measurements of occupational hazards, the following standard methods were used: ISO 7726:1998 "Thermal environments – Instruments and methods for measuring physical quantities" (for indoor climate); DIN 5035-6:2006 "Artificial lighting. Measurement and evaluation" (for lighting); ISO 9612:1997 "Acoustics – Guidance for the measurement and assessment of exposure to noise in a working environment" (for noise); WCB method 1150:1998 "Particulates (total) in air" (for dust); EN 482: 1994 "Workplace atmospheres – General requirements for the performance of procedures for

the measurement of chemical agents"; EN 689: 1996 "Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy"; EN 481:1993 "Workplace atmospheres- Size fraction definitions for measurement of airborne particles"; EN ISO 10882-1:2001 "Health and safety in welding and allied processes- Sampling of airborne particles and gases in the operator's breathing zone – Part 1: Sampling of airborne particles"; EVS-EN 1231:1999 "Workplace

atmospheres – Short term detector tube measurement systems – Requirements and test methods"; WCB method 1150:1998 "Particulates (total) in air".

The results of the measurements in the work environment are given in Table 4 and 5.

The five-stage simple/flexible risk assessment model was used for the assessment of working conditions (Fig. 3). The results of risk assessment in other industries are given in Table 6 and in graphical way (Reinhold et al., 2006; 2009a).
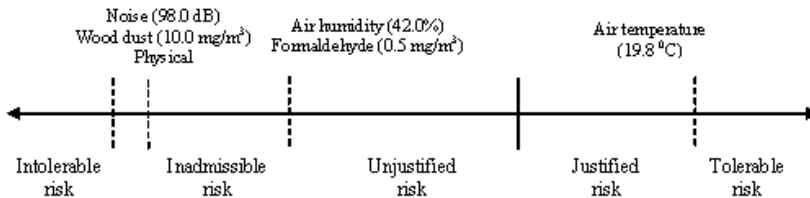


**Fig. 3.** Assessment of work conditions using a simple risk assessment method in the wood processing industry

**Table 4.** The results of measurements of indoor climate and noise in manufacturing

| Industry | Indoor air temperature, $^0C$, $U^* = 0.6\ ^0C$ | | Indoor air humidity, %, $U^* = 2.0\%$ | | Air velocity, workplace, m/s, $U^* = 0.01\ m/s$ | Noise level, dB(A), $U^* = 2.0\ dB$ |
|---|---|---|---|---|---|---|
| | Cold season | Warm season | Cold season | Warm season | | |
| Clothing | 20.3…23.5 | 22.7…25.6 | 44.4…53.0 | 48.2…53.0 | 0.01…0.04 | 62.1…89.5 |
| Printing | 21.7…22.4 | 22.5…24.3 | 38.2…52.2 | 44.2…62.4 | 0.01…0.26 | 66.4…90.3 |
| Wood | 21.2…24.0 | 24.3…26.5 | 34.2…42.6 | 35.1…47.6 | 0.02…0.30 | 84.2…94.4 |
| Mechani-cal | 10.8…21.4 | 17.6…23.2 | 31.3…39.9 | 41.4…48.7 | 0.01…0.21 | 73.0…97.5 |
| Plastic | 14.0…22.4 | 18.6…25.5 | 26.1…40.7 | 36.5…45.7 | 0.02…0.07 | 61.1…83.8 |
| Offices | 18.7…23.0 | 22.4…26.7 | 32.6…47.9 | 39.5…54.6 | 0.01…0.17 | 46.7…62.4 |

**Table 5.** The results of measurements of lighting, dust and chemicals

| Industry | Lighting, lx, $U^* = 10.4\%$ | Dust, $mg/m^3$, $U^* = 0.3\ mg/m^3$ | Chemicals, ppm  or $mg/m^3$ $U = 10…30\%$ | Exposure limits for chemicals, ppm or $mg/m^3$ (Resolution, 2007) |
|---|---|---|---|---|
| Clothing | 525…2040 | 0.4…1.0 (textile dust) | formaldehyde – n.d. | 0.6 mg/ m$^3$ |
| Printing | 264…1625 | 1.2…4.4 (paper dust) | isopropanol - 100 ppm | 150 ppm |
| Wood | 320…1050 | 2.0…10.0 (wood dust) | formaldehyde - 0.5 mg/m$^3$ toluene - 1- 941 mg/ m$^3$ xylene- 2.5-347 mg/ m$^3$ butanol- 0.5- 285 mg/ m$^3$ styrene- 1-208 mg/ m$^3$ benzene- 0.8-1 mg/ m$^3$ | 0.6 mg/ m$^3$ 192 mg/ m$^3$; 221 mg/ m$^3$ 150 mg/ m$^3$ 90 mg/ m$^3$ 1.5 mg/ m$^3$ |
| Mechanical | 88…1256 | 0.7…2.5 (welding dust) | ozone – 0.2 ppm carbon monoxide – 0.1…0.2 ppm carbon dioxide – 120…200 ppm nitrogen oxides – n.d. | 0.1 ppm 35 ppm 5000 ppm 25 ppm |
| Plastic | 138…742 | 2.05…6.04 (general dust) | hydrogen fluoride –  0.5 ppm | 1.8 ppm |
| Offices | 644…2640 | n/m | formaldehyde- n.d. carbon dioxide-800...3000 ppm | 0.6 mg/ m$^3$ 5000 ppm |

(Abbreviations: n.d. - not detected, n.m. - not measured, *U - uncertainty, k=2)

**Table 6.** Determination of risk levels in industrial activities

| *Industry* | *Noise, EL, dB(A)* | *Noise, risk level* | *Lighting, EL, lux* | *Lighting, risk level* | *Dust, EL, mg/m³* | *Dust, risk level* | *Air Humidity, EL, %* | *Air humidity, risk level* |
|---|---|---|---|---|---|---|---|---|
| Clothing | 85 | ID | 500-1500 | T | 1-5-10 | J | 40-60 | J |
| Printing | 85 | UJ | 300-1200 | J | 2-5-10 | J | 40-60 | J |
| Wood | 85 | ID | 400 | UJ | 2-5-10 | ID | 40-60 | UJ |
| Mechanical | 85 | ID | 400 | UJ | 3-5-10 | J | 40-60 | J |
| Plastic | 85 | J | 300-1000 | J | 3-5-10 | J | 40-60 | UJ |
| Water purification | 85 | J | 300-400 | J | 5-10 | J | 40-60 | J |
| Offices | 55 | UJ | 400-500 | J | 5 | n.m. | 40-60 | UJ |

(Abbreviations: EL- exposure limit; IT- intolerable; ID- inadmissible; UJ-unjustified; J- justified; T- tolerable risk; n.m.-not measured)
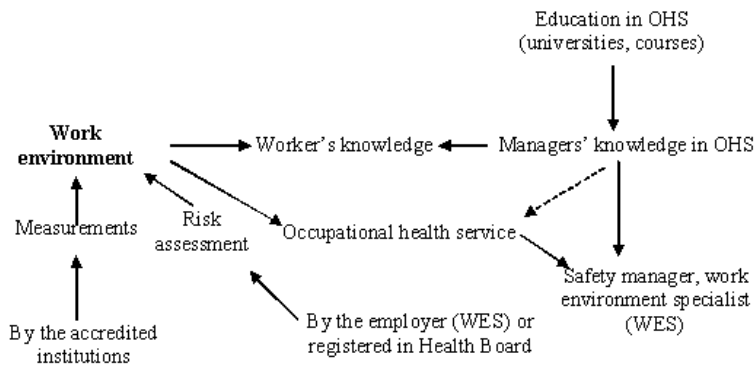


**Fig. 4.** Model for OHS management at enterprises

## 4. Model for safety management at enterprise

The investigation of OH personnel (Järvis and Tint, 2009; Kempinen and Sarap, 2002) showed that one of the main obstacles in the way for improvement of safety culture at enterprises is bad quality of risk assessment. Therefore the knowledge given to the managers and also to workers is very important. A model for OHS management at enterprise was developed, implemented into practise (in 6 enterprises) and the key-elements for improvement the situation at enterprises are (Fig. 4): risk assessment at workplaces, cooperation between the employer and occupational health personnel, knowledge management of managers and workers in OHS.

## 5. Conclusions

Based on the study, the following conclusions can be drawn and remarks should be made:

1. A systemic approach to occupational safety is the key optimizing workplace safety in enterprises. A consistent method for assessing the occupational hazards is recommended. The case studies showed that the simple/flexible risk assessment method created by the authors is viable and applicable in the selected industries assessing physical and chemical risks. The methodology can be used in any kind of company, but small and medium-sized companies are preferred.

2. Using the Estonian experiment, five or four risk levels to characterize risks in a work environment are sufficient and unsophisticated for the employer to understand and use. Triggers need to be in place, so people know how to conduct an effective risk assessment, who to involve and who to inform of the outcome. Preferably, risk assessment should be performed by a person with the necessary technical competence.

3. In the investigated Estonian enterprises, most of the hazards were under control. Noise is one of the main health hazards present in many industries. In the studied enterprises, the noise level exceeded the norms in several cases. The risk to experience noise-induced hearing loss among workers who misuse the protective equipment is significant. The employers should attempt to find additional technical measures to lower the noise levels and encourage the workers to use the personal protective equipment properly.

4. New possibilities for the involvement of workers in the safety management at enterprises have to be considered by the top management of the enterprises. In many of the investigated enterprises, the management's attitude towards occupational health and safety was stimulating and supportive and

the management showed eagerness to enhance workplace safety. However, in several cases it was suggested that the employers should improve the dissemination of information to workers on safety matters, particularly on the accidents and incidents in the enterprise in order to remind them of the importance of following the safety measures for achieving a safe workplace. It is also essential to understand the occupational health and safety needs of an enterprise to allow sufficient freedom to enable workers to use the experience, judgment and skills they have acquired if necessary.

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# Appendix 4.

**Research paper IV**

Järvis, M., Tint, P. (2009). Innovations at workplace: an evidence based model for safety management. *Journal Business: Theory and Practice.* Volume 10, No 2: 150-158. (ETIS 1.2)

# INNOVATIONS AT WORKPLACE:
# AN EVIDENCE-BASED MODEL FOR SAFETY MANAGEMENT

## Marina Järvis[1], Piia Tint[2]

*Tallinn University of Technology, Kopli 101, 11712 Tallinn, Estonia*

*E-mails: [1]marina.jarvis@tseba.ttu.ee; [2]piia.tint@tseba.ttu.ee*

**Abstract.** Safety culture is a sub-unit of organisational culture, which affects members' attitudes and behaviour in relation to organisation's ongoing health and safety performance. Many companies want to enhance their safety culture or some aspect of safety behaviour trying to find the effective way forward. Safety culture in small and medium-scale (SMEs) enterprises has received very little attention in Estonia. Estimates suggest that these enterprises have serious problems aggravated by limited access to human, economic, technological resources as well as lack of relevant occupational health and safety (OH&S) knowledge. The current paper commences with a discussion on the Reciprocal Model of Safety Culture and different perspectives on a framework espoused by Cooper (1999). The concept of safety culture and knowledge management is also discussed. Authors present supplemented Cooper's Reciprocal Model of Safety Culture with Knowledge Management System Dimensions. The exploratory study based on workplace visits and interviews with owner-managers of SMEs manufacturing enterprises gives an overview of the most characteristic OH&S representations and practices. An overview of the current Estonian OH&S system is also presented based on occupational health (OH) physicians' questionnaire surveys conducted in 2002 and 2009. The study suggests that there is need for discussion and improvement of collaboration between employers and OH professionals in order to strengthen knowledge management and infrastructure as well as safety culture at the Estonian enterprises. Competence and expertise in work and health topics is the foundation for the added value of OH professionals to the health of working population.

**Keywords:** knowledge management, safety management, safety culture, work environment.

# INOVACIJOS DARBO VIETOJE:
# KONSTRUKTYVUS DARBO SAUGOS VADYBOS MODELIS

## Marina Järvis[1], Piia Tint[2]

*Talino technologijos universitetas, Kopli 101, 11712 Talinas, Estija*

*El. paštas: [1]marina.jarvis@tseba.ttu.ee; [2]piia.tint@tseba.ttu.ee*

**Santrauka**. Darbo saugos kultūra yra organizacinės kultūros subvienetas, darantis įtaką organizacijos narių požiūriui ir elgesiui, atsižvelgiant į organizacijoje vykdomą profesinės sveikatos ir darbo saugos politikos lygį. Daugelis kompanijų nori pagerinti saugos kultūrą ar tam tikrą aspektą ir bando rasti efektyvių būdų tam pasiekti. Saugos kultūrai mažose ir vidutinėse įmonėse Estijoje skiriama labai mažai dėmesio. Šios įmonės susiduria su rimtomis problemomis, kurias pagilina ribotas galimybės prieiti

prie žmogiškųjų, ekonominių, technologinių išteklių, taip pat žinių trūkumas profesinės sveikatos ir darbo saugos klausimais. Straipsnyje aptariama saugos kultūros ir žinių valdymo koncepcija. Autoriai papildo Cooper (1999) saugos kultūros modelį, įtraukdami ir žinių valdymo sistemos elementus. Remiantis interviu su smulkių ir vidutinių gamybos įmonių vadovais, buvo atliktas tyrimas, kuris atskleidė situaciją, susidariusią profesinės sveikatos ir darbo saugos srityje. Pateikiama Estijos profesinės sveikatos ir darbo saugos sistemos apžvalga, pagrįsta profesinės sveikatos gydytojų anketine apklausa, atlikta 2002–2009 m. Tyrimas parodė, kad reikalingos diskusijos ir bendradarbiavimas tarp darbdavių ir profesinės sveikatos specialistų siekiant pagerinti žinių valdymą bei saugos kultūrą Estijos įmonėse.

**Reikšminiai žodžiai:** žinių vadyba, darbo saugos vadyba, darbo saugos kultūra, darbo aplinka.

## 1. Introduction

Knowledge management and training of workers for knowledge-based work methods (Andriušaitienė *et al.* 2008; Bivainis, Morkvėnas 2008) have attracted employers and governmental institutions (Tvaronavičienė, Korsakienė 2007) in the EU and outside (Gerasymchuk *et al.* 2007). The innovations in economy (Järvis, Tint 2007) and new training methods (Stankevičienė *et al.* 2008; Zabielavičienė 2008) are implemented in all Baltic States.

Knowledge management in occupational health and safety (OH&S) has been investigated during many years for economical and ethical reasons, but the ways of approaching the problem have changed. Safety through technical design is still entirely relevant, but obviously it is not enough. We must try to understand better the psychological and social preconditions for worker's unsafe behaviour and accidents. Organisation culture is a concept used to describe shared corporate values, assumptions, beliefs and norms that join organisational members. At the same time, contrasting perspectives on organisational culture can be also used as a framework for appreciating how values, beliefs and attitudes about OH&S are expressed and how they might influence directions that organisations take in respect of safety culture. In 1986, the concept of safety culture first came into use in connection with the investigation of Chernobyl disaster. Safety culture is a sub-unit of organisational culture, which alludes to individual, job, and organisational features that affect and influence organisation's ongoing health and safety performance (Cooper 2000). UK Health and Safety Commission (1993) define safety culture as *"the product of individual and group values, attitudes, competence, and patterns of behaviour that determine the commitment to, and the style and efficiency of, an organizations health and safety programs. Organisations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy measures"*. Some other researchers (Carnino 1989) have proposed different definitions of similar nature. A lot of companies want to enhance their safety culture or some aspect of safety behaviour. Many managers have started showing an interest in safety performance and their conclusion is that intervention should be directed towards workers and worker behaviour (Järvis, Tint 2009). However, the newest investigations show that the changing of safety climate and culture is really a matter of changing managers' behaviour. The behaviour-based safety approach may be effective for reactive safety management by modifying behaviour and improving compliance behaviour. Behaviour is also one of the main issues (together with situations and person factors) identified in the model of safety culture as the key factor which is applicable to the accident causation chain at all levels of an organisation (Cooper 2000; Heinrich *et al.* 1980).

### 1.1. Models of safety culture

A literature review shows that very few models of organisation (safety) culture exist. Whilst there are differing perspectives within the broad definition of safety culture there appears to be general agreements and common statements, however, when it comes to decomposing culture to its sub-units there appears to be moderate divergence of opinion. An effective development of the culture models started in the 1980s. Accident causation models recognise the presence of an interactive or reciprocal relationship between psychological, situational and behavioural factors (Heinrich 1980). The common thread that can be found in many models is the implicit or explicit recognition of the interactive relationship between psychological, behavioural and organisational factors. Cooper (1999) described organisation culture: "...*the prevailing organisational culture is reflected in the dynamic reciprocal relationship between member's perception about, and attitudes towards, the operation of organisational goals; members' day to day goal-directed behaviour; and the presence and quality of the organisations systems and sub-systems to support the goal-directed behaviour"*. In essence, this definition reflects Bandura's (1986) model (Cooper 2000) of reciprocal determinism derived from Social Cognitive Theory and includes Social Learning Theory. Bandura's reciprocal model suggests a good framework for analysing organisational and safety culture which assesses internal psychological factors (person) and external observable factors (situation and behaviour) in dynamic environment as well as provides a "triangulation" methodology with which to encourage multi-level analyses. Bandura's model (1977, 1986) of reciprocal determinism has been modified and

adapted by Cooper. Based on previous research in the field of safety culture, Cooper proposed a model to reflect the concept of safety culture, that contains three elements: internal psychological factors (safety climate), external observable factors – organisation (safety management system) and job (safety behaviour) (Fig. 1). All elements of this model can also be broken into exactly the same reciprocal relationships, thereby allowing the multi-faceted nature of the safety culture construct to be systematically evaluated by Cooper. His model includes Zohar's (1980) Safety Climate dimension, Safety Management System and Behavioural Dimensions.

Schein (1992) (Cooper 1999) developed a three-layered cultural model that assesses: espoused beliefs and values; core underlying assumptions; behaviours and artefacts. Furnham & Gunter (1993) explored Schein's cultural model and confirmed that the underlying assumptions need to be manifest in some way. Johnson (1992) presents a "culture web", based on Schein's (1992) culture modes, which mainly examines beliefs and values in the organisation. Guldenmund (1998) (Cooper 1999) also demonstrated safety culture as a three-level model, which emphasises behaviours and artefacts, suggests that behaviours might encompass inspections, accidents, near-misses, while safety posters, personal protective equipment could be constructed as artefact. The level one of the Guldenmunds' model analysed organisation policies, management styles, etc. and the second level evaluates the safety climate in order to measure individuals' attitudes and perception about safety. Reason (1997) suggests that safety culture is a sub-culture of corporate culture as well as comprises different sub-cultures among sub-group of people (i.e. department, working group). Reason espouses safety culture dimension of: an informed culture; a reporting culture; a flexible culture and a learning culture. An informed culture (equivalent to a safety culture) is comprised of many types of situational specific cultures (not all of which are safety related), which interact with each other to create the "informed culture". Reason's approach can also be subsumed within the psychological, behavioural and situation components of the reciprocal model (Cooper 2000). The dynamic and interactive relationships between person, environment and behaviour were proposed in a "Total Safety Culture" model by Geller (1997), which estimates 10 core values for the total safety culture. Safety Culture Maturity Model (Fleming 2000) assesses core components as follows: management commitment, communication, productivity versus safety, safety resources, learning organisation, participation, shared perceptions about safety, trust, industrial relations and job satisfaction as well as training.

## 1.2. Impact of safety culture and knowledge management on occupational health and safety

The growing complexity and dynamic of the global economy widen the potential impact of knowledge on today's business enterprises (Hejduk 2005). Knowledge has been recognized as a new resource in gaining organisational competitiveness and it is also the central resources in the achievement of the goal of OH&S management. Active interest in OH&S requires that the workers and employers have the right information at the right time to make a decision affecting health and safety. Knowledge and information is a precondition for action. Proving useful information to decision-makers (including employers, government officials, OH&S professionals, unions and workers) is essential in addressing OH&S issues (Järvis, Tint 2007). Despite the growing interest in knowledge management (KM) studies, only a few (Sherehiy, Karwowski 2006; Schulte *et al.* 2003, 2004) researches were carried out in the field of OH&S. In the context of the management of OH&S, special attention should be given to tacit knowledge, because the research topics are often identified through direct human experience in the workplace, and the results of the research are often immediately applicable to the solution of a problem. When people solve complex problems in the field of OH&S, they bring knowledge and experience to the situation and as they engage in problem solving they create, use and share tacit knowledge (Järvis, Tint 2007). Sherehiy & Karwowski (2006) suggested that the principles and tools of KM should be used to facilitate the management of the existing individual (personal) knowledge, structural knowledge (i.e. knowledge codified into manuals, reports, databases, data warehouses) and organisational knowledge (activity of learning within the organisation) in the fast domain of practical application. In order for OH&S knowledge to create value, it must be shared. Although knowledge sharing and knowledge transfer are often used interchangeably. *Knowledge sharing* refers to the exchange of knowledge between two individuals and focuses on human capital. *Knowledge transfer* focuses on structural capital and the transformation of individual knowledge to group or organisational knowledge, which becomes built into process, products and services (Jakobson 2006). Many Estonian OH&S legislations and regulations contain stipulations about disseminating and applying information concerning OH&S. From a legislative perspective, improved dissemination of information and knowledge should encourage awareness, urge precaution, and lead to a reduction in occupational morbidity and mortality. The process of KM and knowledge transfer at the state level in Estonia was analysed in recent years (Järvis, Tint 2007). According to the study results the main ways of knowledge transfer in the field of OH&S in Estonia are via communities of practice, the Internet and training.

However, there is little known how employers, workers and OH&S professionals receive, analyse, share and use this information.

It is well known that organizational culture plays an important role in the successful implementation and operation of KM and information systems (Balthazard, Cooke 2004). The authors believe that certain aspects of safety culture may play a more pronounced role in the successful adaption of KM practice and systems. The complimentary factor for ensuring optimal OH&S information and knowledge transfer and flow (in KM process) is a supportive and harmonized safety culture shared by all organisational constituents. The safety culture of an organisation is shaped by many factors, some of which can be changed. In this paper authors present useful perspective on safety culture and knowledge management.

## 2. Objectives of the paper

In the light of the above literature survey, authors decided to carry out an exploratory research in order to produce a first picture of safety culture (its components) in Estonian small and medium-scale (SMEs) enterprises. More specifically, the research goal was divided into four parts, as follows:

1. Assess the safety culture elements in Estonian SMEs. Describe the manager's attitudes, knowledge level and concerns in this regard.
2. Suggest and show the innovative possibilities for improvement of safety culture at the Estonian SMEs through complex approach to safety and health, which includes knowledge management system.
3. Target at the occupational health and safety problems specific to SMEs and identify the main priorities and major problems in the relevant system in Estonia.
4. Evaluate the attitudes, professional skills, knowledge of occupational health physicians; investigate their role in creation of safety culture at the enterprise.

## 3. Methodology

### 3.1. Case studies

Case studies were seen to promote better understanding of the rationale of current safety culture, the development need and obstacles. Based on the information gained through case studies as well as review and analysis of the literature drawing from several databases, authors stated the development of model system for safety culture.

The exploratory study based on workplace visits and semi-structured interviews with owner-managers of 7 small and medium-scale (SMEs) manufacturing enterprises were carried out using validated questionnaires. Of these, 2 were in wood processing sector, 1 was in the cloth-

ing manufacturing sector, and 1 in printing industry, 2 and 1 were accordingly in mechanical industry and plastic industry. Each interview lasted an average of 20 min. in order to evaluate the management's commitment to safety; worker's involvement in safety. In addition, the data from 18 enterprises were used for assessment of safety culture as well as to examine specific to SMEs problems in the OH&S system. The enterprises were located in different parts of Estonia, however major of them in or around the capital and western part of the country. Methods which have been used are as follows: observation, risk assessment, documentation overview, safety rules and procedures.

### 3.2. Survey of the practice of occupational health professional

The substantive parts of the article present comparative survey evidence from questionnaire surveys which were conducted in 2002 and 2009. The method used was administration of a self-completed questionnaire with 10 groups of questions to all occupational health professionals who were according to the Estonian Act of Occupational Health and Safety practising as occupational health (OH) physicians. The questionnaire consisted of main parts: identification data, questions on awareness and use of information sources, attitudes to ethical issues, their everyday tasks and duties, their perception and assessment of safety culture at the Estonian enterprise, cooperation with employers, strengths and weaknesses of the current OH&S system in Estonia, etc. Only qualitative data is presented in the current article.

## 4. Qualitative findings

### 4.1. The results of safety management and culture investigated in companies

The study was conducted in small and medium-scale enterprises, because the number of such type of companies are around 50 000 in Estonia. The summary of the companies is presented in Table 1. In each company, the management attitude towards health and safety (i.e. the supportive actions to provide adequate information, investments in OH&S, etc.) was assessed on the basis of the interest in the results of outcomes of the research. The awareness and supportive actions of company management for the problems of OH&S were assessed as stimulating/supportive, neutral or impeding/ negative. It has to be highlighted that as regards daily routine, formal or informal assignment of OH&S responsibility and participative management practices are not very common in the investigated SMEs. Although most of the managers said they entrusted some OH&S responsibilities to their employees, it was not examined what are the means available to help those employees to assume their responsibilities. There is

Table 1. Summary of the investigated companies

| Industry | Companies | No. of workers | Awareness of company management |
|---|---|---|---|
| Wood processing | 5 | 25...200 | + (2 cases) ± (2 cases) – (1 case) |
| Clothing industry | 5 | 120...225 | + (4 cases) ± (1 case) |
| Printing industry | 3 | 24...140 | + (2 cases) – (1 case) |
| Mechanical industry | 2 | 90...175 | ± (2 cases) |
| Plastic industry | 3 | 25...180 | + (1 case) ± (2 cases) |
| Office rooms | 18 | 15...100 | + (9 cases) ± (7 cases) – (2 cases) |

*Abbreviations: "+" – stimulating, supportive; "–" – impeding, negative; "±" – neutral*

a lack of resources at the SMEs enterprise in order to hire the working environment specialist/ safety manager who would deal with the OH&S problems. Generally, these responsibilities are divided between different specialists in various departments. SMEs have special problems with the work environment: the risk is higher and the ability to control risk is lower. There are also studies indicating that exposure to physical and chemical hazards is higher in SMEs than in large companies (Soresen *et al.* 2007) and there is no reason to believe the opposite concerning Estonian enterprises due to absence of the appropriate research. The level of safety performance, managers' and workers' knowledge in OH&S was various in different investigated enterprises. The enterprise's safety performance depends on the following components: surveillance of working conditions, workers' knowledge management, safety management system and cooperation with OH professionals (Reinhold *et al.* 2009). Two thirds of respondents consider the risk to their employees' health sufficiently low. However, majority of the interviewed managers had a certain plan of activities to improve working conditions. An interesting finding was also that none of the interviewed managers had tried to evaluate the economic losses that had been caused by employees' sicknesses and/or occupational accidents. According to the results from interviews, there is a lack of workers' involvement in the safety practice and cost-benefit analysis of interventions made in working environment. The main results of the study were as follows: the lack of managers' awareness in the field of OH&S, especially among non-Estonian employers; the absence of the safety policy; the accident investigation and

reporting procedures were weak (Kempinen, Tint 2006); low quality of risk assessment; insufficient safety training provided to workers; lack of effective cooperation with OH physicians.

## 4.2. Questionnaire study of occupational health physicians

The role of OH physician in private sector is changing. Occupational medical services for employees previously covered by in-house are now provided by outsourcing since 2003 in Estonia. According to the Estonian Act on Occupational Health and Safety, only entrepreneurs or private medical health professionals may now provide the services. The private practice of occupational medicine has become the growth area of the speciality in Estonia. For several years the number of active OH physicians is slightly increased. These trends have been driven primarily by new OH&S legislation, economic imperatives and new management philosophy. However, it is not clear that organisations in general are deriving the greatest value they can from their OH physicians and that the managers are effectively cooperating with their OH professionals. In order to investigate OH physicians' attitudes and perceptions towards their cooperation with managers and working environment specialist, questionnaire surveys were conducted in 2002 and 2009. During the first survey, questionnaires were distributed to 103 Occupational health professionals (OH physicians, nurses, hygienists and ergonomist) in 2002 and response rate was 40 % (Kempinen, Sarap). In the present article only OH physicians' responses are used. All active OH physicians received similar questionnaires in 2009 and 48% of them completed the questionnaire. As was mentioned before, the number of OH physicians has increased since 2002, therefore the work experience in the field of OH&S of OH physicians was longer (21.4 years) in the first study (in 2002) than in the second in 2009 (11.3 years). The results from both surveys indicated that the majority of OH physicians (46 %) were working in OH units (department) in hospital and 30% - in occupational health services (OHS). Almost all of the OH physicians (98%) reported that they had attended the specialisation courses for OH physicians and all respondents had received training in the field of OH&S. During the first study in 2002, the main educational centre for OH physicians was the Estonian Occupational Health Centre. In 2004, changes in the political climate concerning OH&S issues led to reorganisation of the Labour Department at the Ministry of Social Affairs in Estonia. At the same time, the Occupational Health Centre as the only one competent OH&S authority in Estonia was closed down; its responsibilities were distributed between different State organisations (Labour Inspectorate, Health Care Board). However, at the moment, there is no one competent au-

thority who would deal wholly with complex OH&S issues (i.e. research, expertise, training, consultancy, guidelines, etc.) and would be responsible for coordination, creation and dissemination of OH&S information and knowledge. There is a policy dimension to this debate that must also be acknowledged.

During the second survey, more than half (55.6%) of the participants in the survey stated that they received their specialisation and relevant training at the Tartu University. Important finding was that during the both studies, among the 15 main topics related to OH&S, OH physicians in 2002 and six years later considered issues of occupational diseases and work related diseases (diagnostic and prevention), OH&S legislation and rehabilitation and/or promotion of work ability to be the most important issues for the future training. Currently, many respondents revealed that they tend to work on a part-time basis as OH physicians, serving more than one employer and often have a short-term contract with employer. This can be explained based on the relevant Estonian OH&S law. According to the law, the employer is obligated to organize OHS for the employees and to bear the costs incurred. The services provided by an OH physician, OH nurse, a hygienist, a psychologist or an ergonomist are considered to be OHS. According to the law, the statutory requirements are met if the employer acquires the services from any of the individual specialists and multidisciplinary provision of OHS is not required. The other important factor is that family physicians still often are recruited into workers' health surveillance, which is at variance with Estonian legislation and good occupational health practice (GOHP).

The most commonly reported activities among OH physicians were performing the health examination, rehabilitation/planning of rehabilitation and workplace visits. Besides above listed activities, minority of OH physicians were involved in advising and consulting the working environment specialists and employers; dealing with activities related to maintaining work ability and making the expertise of occupational diseases. According to OH physicians' responses (59.5%) Estonian employers are generally well informed about their OH&S responsibilities and 62% of respondents stated that employers are ready for cooperation with OH physicians. More than a half of OH physicians revealed that employers always (11.8%) and often (54%) follow the advice and recommendations given by OH physicians after workers' health surveillance. At the same time, 27% of the respondents stated that employers have little motivation from the legislation to deal with OH&S issues. These findings confirmed the Martimo (2004) and Kempinen, Kurppa (2004) findings. Interestingly, that according to OH physicians' responses from the second survey (2009), the main priorities and major problems in the current OH&S practice in Estonia were exactly the same

as were reported by OH professionals in 2002 (Kempinen, Sarap 2002): lack of political commitment of the government and social partners to be able to draw up policies for further development of OH&S; non-sufficient legislation (the absence of the Compulsory Insurance Act of Occupational Diseases and Accidents); the absence or low quality of risk assessment; there is no agreement between the OH physicians and the Estonian Sick Fund in order to compensate costs for the analysis and rehabilitation of workers. There is also low coverage of the OHS offered to employees and lack of the OH&S professionals as well as lack of the research activities in the field of OH&S. Results of the first survey (2002) and an overview of the present OH&S situation in Estonia were analysed in detail (Järvis, Tint 2009; Kempinen, Sarap 2002; Martimo 2004) and the description of the factors influencing safety culture in Estonian enterprises were presented. Based on the information about the present OH&S situations, authors would like to propose that OH physicians be looked at in a new way as a fresh resource of knowledge and competence with defined capabilities, and that their position description be developmental that emphasize these capabilities at the state as well as organisational levels. Process of OH&S knowledge creation and transformation, prevention, risk anticipation, risk assessment and management are perhaps the areas where OH physicians can make the greatest contribution. Since risk anticipation requires a broader perspective, team work, balancing resources and priorities, in addition to working environment specialist who coordinates OH&S at the organisational level, qualified and well-prepared OH physicians should be effectively involved and certainly can contribute to definition and solution of the OH&S problem as well as improve the safety culture at the enterprise.

### 4.3. Modified model of safety culture

As it was described in part 1.1 "Models of Safety culture", there is already an understanding of the factors that affect safety culture. Fig. 1, for example, shows a useful framework developed by Cooper (2000) which contains three
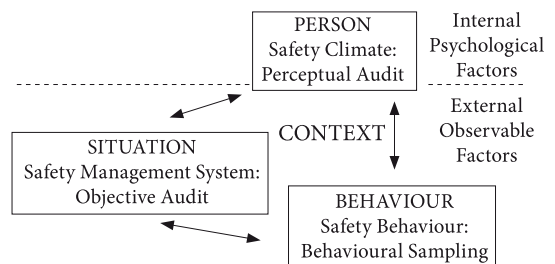


**Fig. 1.** Basic safety culture model (Cooper)

main aspects: psychological aspects (often called "safety climate") – how people feel; behavioural aspects – what people do, and situational aspects – what the organisation has or has put in place. This combination of factors is making the complexity of factors clear – they are related to people, their behaviour and their interactions with the safety management systems of the organisation. It is also known, that dissemination of OH&S information and KM are important aspects for effective and successful managing of health and safety in the enterprises. Authors have presented an adopted and modified Cooper's Model of Safety Culture with Knowledge Management System Dimensions, which can allow in-depth studying of the impact of KM on development of safety culture processes. The model proposed takes into account the dynamic inter-relationships between safety climate, safety management systems, safety behaviour and motivational strategies, helps to create, transfer and utilize safety knowledge (KM system). Authors suggest that organisations should pay more attention to how their OH&S knowledge is managed (how knowledge is created, transferred and used by workers) in order to develop positive safety culture. The suggested knowledge elements of the model can also be broken down into exactly the same reciprocal relationship

(Fig. 2). Presented reciprocal model provides a comprehensive way of thinking about the many processes and aspects that might impact on safety culture. The concept of the presented model is also partly related to Reason's (1997) "informed (or safety) culture" model, which includes dimensions of an informed, a reporting, a flexible and a learning culture.

## 5. Discussion and conclusions

A set of publications (Sherehiy, Karwowski 2006; Schulte *et al.* 2004) indicates that in order to improve the management of OH&S system there is need to develop the principles and tools of KM in the area of application at the state as well as organisational level. Even though rapid improvement has been made in the field of OH&S in Estonia in recent years, there are still challenges ahead. At the state level, decisions concerning OH&S are planned without paying careful consideration to the whole OH&S system. This is mainly because only scarce data are available for decision making. The process of KM in the field of OH&S at the state level and major problems were identified and several possibilities for improvements in Estonia were discussed by some researchers (Järvis, Tint 2007; Kempinen, Kurppa 2004; Martimo 2004; Reinhold *et al.* 2009).



**Fig. 2.** Reciprocal Model of Safety Culture

The contribution of the present paper consists of the presented modified Cooper's Model of Safety Culture with the concept of KM. An overview of the safety culture in SMEs was evaluated through workplace visits and semi-structured interviews with owner-managers. In addition, the main problems of the current Estonian OH&S system are presented based on the results of OH physicians' questionnaire surveys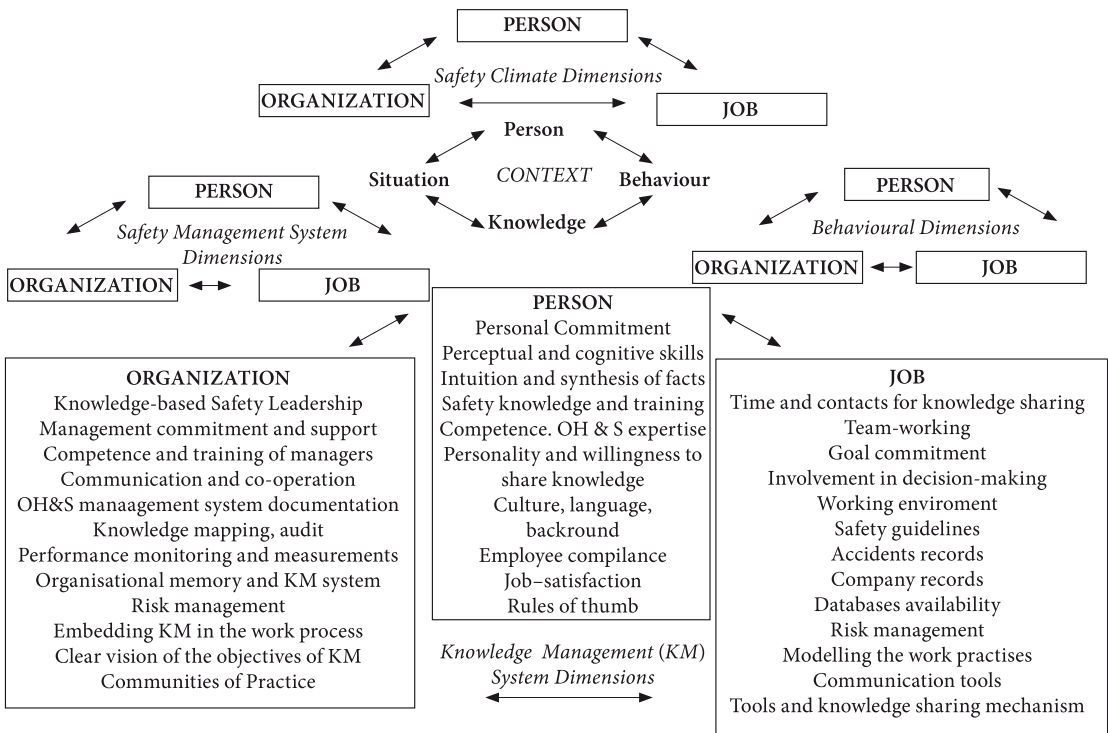 conducted in 2002 and 2009. Based on the previous research and the results of the study it is possible to conclude that there is urgent need for the knowledge-based change in the field of OH&S in Estonia, which could be also one of the effective and most powerful strategies for organisational development. KM process can be seen as a tool for improvement safety culture and safety performance at the Estonian enterprises. There is also need for an effective KM training –support system in order to provide an organisation with strategic advantages and help to develop learning environment, which can help create and maintain skills in OH&S and therefore create the positive safety culture. There is potential for organisations to learn, adopt and apply bets practice, knowledge and information in the field of OH&S from other companies and professionals. Based on surveys, authors emphasise that two main factors in the KM process are essential for strengthening and enhancement of OH&S system: community of practice and supportive and harmonized safety culture. The study suggests that there is need for discussion and improvement of collaboration between employers and OH professionals (development and expansion of communities of practice) in order to strengthen KM and infrastructure as well as safety culture at the enterprises. Authors commend that the greatest value in OH physicians services may be in the anticipation of risk related to health issues and the flexibility this gives the organisation to manage the OH&S problems and to improve safety culture in Estonian SMEs. The added value in OH physicians is based upon the expertise in OH&S issues they can offer to organisations and workers. Authors believe that presented Reciprocal Model of Safety Culture with KM System Dimensions can assist in the ongoing analyses and implementation of a positive safety culture.

## 6. Further research

The next phase of the research, involving more careful and in-depth analysis of the results from two OH physicians' questionnaire surveys, is further research to test the proposed by authors model of safety culture.

Authors also planned the first longitudinal study of OH&S approaches to the workplace level in Estonia, which will allow gaining insight about various organizational factors that might have influenced the workplace level of OH&S, practices and attitudes to SMEs over the past dec-

ade, as well as to assess the improvement made after accession of Estonia into the EU. This study will include similar workers' questionnaire study in 2009 that was already carried out in 2001-2002; one-to-one interviews with senior managers from older and newer companies, which may help elucidate changes in OH&s practices over the course of a firm's history, how they affect the priority of OH&S according to management. In addition, stronger data are needed on factors involved in safety knowledge creation, transfer and translation into practice, especially focusing on KM for young workers and non-Estonian speakers.

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**Marina JÄRVIS (Kempinen until 2006).** Master of Science in Philosophy of Occupational Health (Bergen University from 2001), PhD Stud. at the Faculty of Economics, Tallinn University of Technology (from 2004); Engineer of Biotechnology (TTU, 1998). Employment: Assist. Prof. of Work Environment and Safety (TTU, from 2001). Publications: over 20 research papers. Research interests: knowledge management, economic aspects of occupational health and safety.

**Piia TINT.** PhD (Tehn., Leningrad Technological Institute of Lensoveta) from 1977. Chemical Engineer (TTU, 1970). Advanced training in the Nordic Institute of Occupational Health (NIVA, 13 courses). Employment: Prof., the Head of the Department of Work Environment and Safety (TTU, from 2000). Supervised dissertations: 5 Master theses, 3 PhD students. Has taken part in several international conferences and in 3 international and 2 national research projects. Member of Human Factors Society (Europe Chapter), Finnish Ergonomics Society. Publications: over 100 research papers, 7 books. Research interests: risk assessment, safety and economics.

**Appendix 5.**

**Research paper V**

Järvis, M., Virovere, A., Tint, P. (2013). Formal Safety Versus Real Safety: Quantitative and Qualitative Approaches to Safety Culture – Evidence from Estonia. *Proceedings of the Latvian Academy of Sciences* (forthcoming, ETIS 1.2).

# FORMAL SAFETY VERSUS REAL SAFETY: QUANTITATIVE AND QUALITATIVE APPROACHES TO SAFETY CULTURE – EVIDENCE FROM ESTONIA
## Marina Järvis*, Anu Virovere ** and Piia Tint ***

*ABSTRACT*

This paper examines differences between formal safety and real safety in Estonian small and medium sized enterprises. The data reveal key issues in safety culture assessment. A statistical analysis of safety culture questionnaires shows many organizations with an outstanding safety culture and positive safety attitudes. However, qualitative data indicate some important safety weaknesses and aspects which should be included in process of evaluation of safety culture in organization.

* Doctoral Student, Department of Business Administration, Tallinn University of Technology, Estonia. marina.jarvis@tseba.ttu.ee (corresponding author)

** Doctoral Student, Department of Business Administration, Tallinn University of Technology, Estonia. anu@avpartnerid.ee

***Professor, Chair of Labour Environment and Safety, Department of Business Administration, Tallinn University of Technology, Estonia. piia.tint@tseba.ttu.ee

*INTRODUCTION*

A safe and healthy working environment is an important element of work life quality (Fugas et al., 2012) and many researchers have shown a strong interest in the behavioural aspects of safety, while safety culture and safety climate have become an essential cornerstones of modern thought about occupational health and safety management in organizational culture (DeJoy, 2005; Frazier et al., 2013; Rao, 2007). One of the biggest challenges for organization in today's competitive business environment is to create and preserve a self-sustaining safety culture (Rao, 2007). Researchers and practitioners have shown increasing interest in safety culture and in possibilities' to maintain and improve it because of its impact on safety outcomes such as occupational accidents and fatalities, safety behaviours (Choudhry et al., 2007; Fernández-Muñiz et al., 2007). Safety culture (a sub-unit of organisational culture) does not have a unique and universal definition (Frazier et al., 2013). However, it can be defined as a the product of the individual and group values, attitudes, beliefs, risk-perceptions (Lee and Harrison, 2000), competencies, norm, principles, and patterns of behaviour that determine the commitment of employees to health and safety, as well as the style and proficiency of an organization's health and safety programmes (The Health and Safety Executive, 2005). Cultural assumptions and propagated values are typically the basis of an organization's mission and 'vision statements' which should be a reference for appropriate conduct for all employees in organization. Frazier et al. (2013) stated that this is not always the case, the organization's mission and values cannot create or change a culture alone. Interventions directed at the individual employee level are necessary. It is essential that employees' health and safety behaviour as organizational values are adopted and

shared between all employees throughout the organization and not only formally exiting on paper. Reviews of organizational values surveys have identified some common constructs related to such values (Virovere et al., 2013) as: described, propagated and shared or real values; formal or real values. Employees' attitudes and safety behaviour are based on adopted and recognised values. Therefore it is essential, that applying these values is achieved through management principles, good practices in occupational health and safety, as well as through employers' and employees' commitment to safety on a daily basis.

Many organizations claim to have a serious commitment to safety and they show relevant good safety performance, accident records. However, this positive phenomenon could be similar to a formal, propagated and image-based approach to safety and needs to be investigated in-depth, focusing on the differences between 'formal' safety and 'real' safety. Meliáa et al. (2012) investigated differences between descriptive and prescriptive safety cultures, and analysed the effort of the construction industry to convert formal safety into real safety in a large plant. An in-depth safety culture analysis showed how a very positive prescriptive safety culture as described by questionnaires may not be enough to reveal important safety culture flaws and fix underlying safety risks.

The present article examines differences between formal safety and real safety in Estonian small and medium sized enterprises from different industries and discusses one of the many possible approaches to safety culture - through managing the safety social capital inherent in organization. This study is a first step in the process of applying intellectual capital (IC) principles to the field of occupational health and safety (OH&S) in Estonia with a special focus on knowledge management (KM) systems as an umbrella for capturing a range of organizational concerns towards health and safety. This article concerns organizational safety culture and the structure or architecture of employees' and employers' attitudes to safety as part of that culture, as well as the ability to learn, which also should mean changes in worker's behaviour in order to enhance safety culture. The article proceeds as follows: First, we introduce the concept of IC as the stock of knowledge and skills that an organization is able to generate and use in its OH&S management system to build safer and healthier workplaces. Also this section reviews the content of social capital (SC) and its relationship to shared knowledge and safety culture in the organization. Second section outlines the methods used in the research. The last sections present an analytical overview of the existing Estonian organisational safety culture, which requires consideration of both SC and safety managements system in organizations. Safety as an organizational value is evaluated and the differences between formal safety and real safety are assessed. In addition, safety programmes are evaluated in small and medium sized enterprises (SMEs) in order to highlight the social and cultural character of learning in organizations, and thus attribute the role of SC in safety knowledge exchange. The authors' recommendations and argument conclude with a view of SC and organizational learning concepts toward OH&S in the light of on-going problems of safety culture in Estonia.


1. **Organizational safety social capital and safety culture**

In this section intellectual capital (IC) and social capital (SC) are described. In addition, the terms and concepts of knowledge management (KM) and safety culture are also presented.

Organizational sustainability may be assessed and evaluated through its IC and SC. According to the sociological view of learning, individuals in organizations

continuously obtain, combine, modify and use knowledge through their everyday cooperation and interaction (Chang et al., 2011). Nahapiet and Ghoshal (1998) have stated that organizations have potential and capabilities for developing, creating, sharing and utilizing knowledge and IC, as well as the development of and cultivation of SC are likely to realize a competitive advantage. Roos et al. (1997) conceptualised IC as the sum of all intellectual materials – knowledge, information, intellectual property, skills, experience and knowing capabilities of companies – that can be combined and utilised for competitive advantage. IC is a collective brainpower, which can be developed through the processes of sharing and the combination of knowledge (Bahra, 2001). In order for the IC to succeed within an organization, the sharing of knowledge needs to be managed effectively. Knowledge development in an organization is dependent and influenced by the organization's SC (Davenport and Holsapple, 2006). Therefore, the organization encourages development of SC and, hence provides possibilities and creates a structure for sustained interaction, conversations, socialization, teamwork and cooperation between its members in order to create the new IC and knowledge. Nahapiet and Ghoshal (1998) stated that there are four main conditions which must exist in an organisation that enhance SC and stipulate the creation of new IC through exchange: (1) opportunity (access to parties for combining/exchanging IC), (2) expectation of the creation of value (anticipation of value through combining/exchanging IC), (3) motivation to combine/exchange IC and (4) capability. SC is frequently described and defined as one of the three subcategories of IC (See Figure 1), a) human capital (consisting of the employees' and manager's knowledge, skills, experience and abilities of the individuals) and b) organisational or structural capital (covering the structures and processes within the organisation, referring to knowledge institutionalised within databases, documents, manuals and culture) and c) SC (consisting of valuable relationships, networks) (Camps and Marquès, 2011; Nahapiet and Ghoshal, 1998). Edvinsson and Malone (1997) suggest that corporate value does not arise directly from any of its IC factors, but only from the interaction among all three.

According to Putnam (1993) SC has the following features: active participation in social networks, reciprocity, trust, and respect for social norms. Fukuyama (2001) defines SC as instantiated informal values and norms, which enable and promote cooperation between members. At the same time, Fukuyama (2001) emphasises that just existence of the collective norms, asset and values does not necessarily develop and create SC in organizations. SC as the organizational process requires bringing people together, creating interdependence through integration and specialization (Davenport and Holsapple, 2006). Coleman (1988) describes SC as "consisting of aspects of social structure and identifies three forms of social capital: obligations and expectations, information channels and norms that influence and encourage behaviour". In addition, he makes the comparison of SC with other forms of capital, such as human capital and physical capital, and outlines that SC is productive, less tangible, partially fungible and partially specific to a setting, being embodied in the relations among persons.

The current research employed the definition and modified model provided by Nahapiet and Ghoshal (1998) with respect to safety, which consists of structural, cognitive, and relational dimensions of SC.
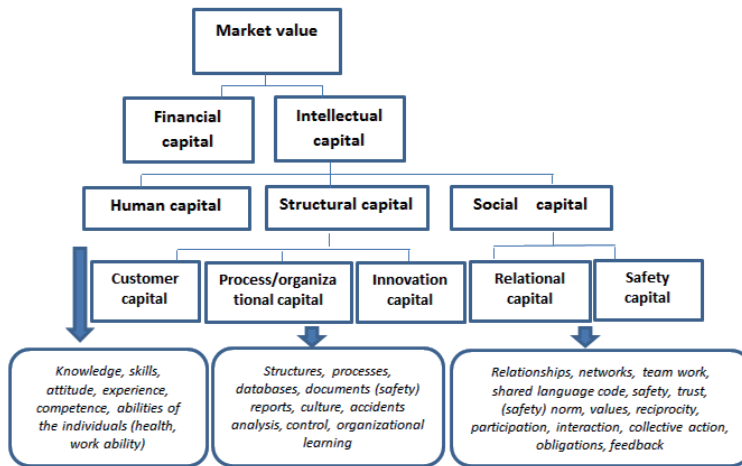
Figure 1. The Intellectual capital distinction tree (based on Roos, et al., 1997).

The authors have elected to adopt this definition and framework because it clearly demonstrates the interrelationship between SC and intellectual capital, through which the collective learning is enabled and engaged. In addition, their framework provides a relevant interpretation on how SC can be used for development of IC in an organization (Bolino et al., 2002; Koh et al., 2012). The *structural component or dimension* of SC consists of connectedness, networks, employees' participation and behaviour (Harpham et al., 2004). The most important "properties of the social system and of the network of relations as a whole" (Nahapiet and Ghoshal, 1998, p.244) include: network ties, which provide the channels for relevant information transmission and it is a social relations that provides information benefits in the form of access, timing and referrals; network configuration within a set of relationships and existence of appropriable organization structure, which is created for one purpose that may be applied and used as a valuable resource for another purpose (Davenport and Holsapple, 2006; Koh and Rowlinson, 2012). The *cognitive component or dimension* of SC comprises: shared norms, sanctions, goals (Coleman 1988; Putnam 1995), shared representations, meaning and vision, social trust, perceptions of support, social cohesion and attitudes, shared interpretations and understanding between the members of a network (Fukuyama, 2001; Koh & Rowlinson, 2012; Nahapiet and Ghoshal, 1998) that facilitate coordination and cooperation for mutual benefit. Examples here are shared language and codes, shared collective narratives and ontologies. An important facet of the *relational component or dimension* of SC comprises: trust that is developed among members; personal relationships that members develop among themselves through a history of interaction (Davenport and Holsapple, 2006). This dimension of SC is derived from organization's culture and sub-culture, such as safety culture, and includes: norms, obligations and identification (Davenport and Holsapple, 2006; Nahapiet and Ghoshal, 1998). At the same time, communication, participation in decision-making, sharing valuable knowledge and sharing attitudes and view-points (Davenport and Holsapple, 2006), employees' involvement in processes, as well as social good relationships and conflict management are an essential factors that promote trust. In order to achieve the collective and shared goals and visions as well as attitudes and understanding between the members of a network, an effective KM

4

system is required and presumed. KM is an integrated, systematic approach which can also be used to describe the structures, processes, techniques, methods, and cultures developed to improve the creation, identification, management, sharing and utilization of an all organisation's resources/assets, including data bases, documents, policies, procedures as well as expertise and experience of individual workers (Alvesson, 2004; Roos et al., 1997). The KM system is an umbrella for capturing a range of organizational activities in order to manage the integration of human, structural and social capital in order to enhance learning and performance in organization (See Figure 2). Organizational learning is a process during the organizations share, create, spread, and expand their knowledge, connecting from groups to organization (Chang et al., 2006). This is also a tool for development of Communities of Practice (CoP) and potentially gives a possibility for employees to exchange explicit and tacit knowledge. According to Hislop (2005), CoP is realised in informal groups of people who have a particular activity in common, and as a consequence have some common values, knowledge, and a sense of community identity.
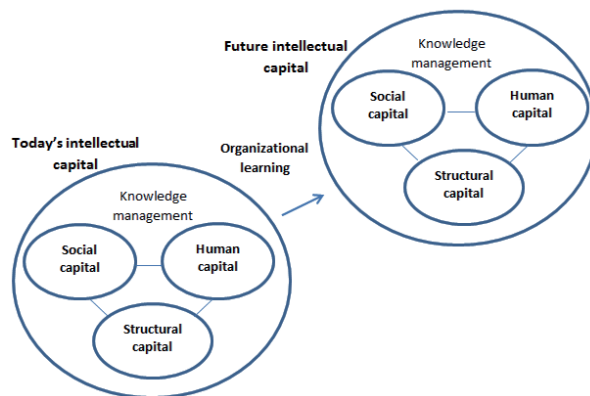


*Figure 2. Intellectual capital grows with use and requires Organizational learning (Seemann, et al. 2002)*

Jashapara (2011, p 47) has stated, that from an interdisciplinary perspective, KM can be also defined as: "the effective learning process associated with exploration, exploitation and sharing of human knowledge (tacit and explicit) that use appropriate technology and cultural environment to enhance an organization's IC and performance". Therefore, a KM system is needed for accumulation of the SC and shows its effect in the creation and transfer of knowledge in organisation. An essential characteristic of knowledge is that it only generates value for the organization when it is used effectively (Seemann, et al., 2002) and shared (Järvis and Tint, 2008).

SC has emerged as an area of the interest to a large number of researches and has been studied at different levels, including organisational (Burt et al., 2000; Chang et al., 2011; Coleman, 1988; Loosemore and Lam, 2004; Koh and Rowlinson, 2012; Nahapiet and Goshoal, 1998; Nuñez and Villanueva, 2011; Rao, 2007), communities (Putnam, 1993), individuals and their behaviours (Burt et al., 2000; Lindström et al., 2003) and nations (Fukuyama, 2001). Researchers from different disciplines have investigated the relationship between organizational knowledge and SC (Chang et al., 2011; Peltomäki and Husman, 2002). Felício et al.(2012) investigated relationships

between SC and human capital in SMEs. The positive effects of SC connections to KM was studied by Burt et al.(2000) and Nahapiet and Ghoshal (1998); CoP (Gherardi and Nicolini, 2000; Wenger, 2000), knowledge transfer (Wei et al., 2011), organizational learning (McGrath and Sparks, 2006); improving creativity and innovativeness (Camps and Marquès, 2011; Chang et al., 2006).

The description and characterization of SC, when applied to working life describes the situation that in Europe used to be described with the words: 'good job – good workplace' (Järvis and Tint, 2009b). It is widely recognized that safer and healthier workplaces are, along with competitive advantage, one of a firm's major objectives, as they can improve productivity, boost employees' morale and reduce costs (Nuñez and Villanueva, 2011). At the same time, the occupational health and safety (OH&S) practices are rarely considered within the resources of IC of the organization. Several researches have tried to provide some preliminary evidence on the role of organizational knowledge in building safer and healthier workplaces (Gherardi and Nicolini, 2000; Nunez and Villanueva, 2011; Podgorski, 2010; Smith-Crowe et al., 2003; Zohar, 1980) and in enhancing safety culture. At the same time, relatively little is known about how organizations influence and deal with the formation of safety culture with respect to SC among their employees. However, there are some surveys investigating the concept of SC for OH&S (Chang et al., 2011; Gherardi and Nicolini, 2002; Koh and Rowlinson, 2012; Rao, 2007); organizational knowledge and SC (Koh and Rowlinson, 2012; Nuñez and Villanueva, 2011; Rao, 2007). For example, Chang with colleagues (2011) examine the influence of SC on knowledge sharing, which in turn enhances patient safety. Koh and Rowlinson (2012) investigated a relationship approach to managing construction project safety. The results from their study highlight the fact that the project organisational processes, team practices, and quality of relationships between participants shape the team capability in safety management.

### 1.1.      The concept of safety social capital

In the field of industrial safety, knowledge is the central resource in the achievement of the goals of occupational health and safety management (OH&S). OH&S is a functional subsystem of the organization, which adopts and applies of tools, ideas, principles and aspects of general business administration (Nuñez and Villanueva, 2011). Reiman et al. (2005) stated that an organization has a high potential for safety and positive and strong safety when the following criteria are met in the organizational activity: safety is a clearly recognised value and understood as a complex and systemic phenomenon; safety is integrated into all daily activities; organization is mindful in its practices and activities are organised in a manageable way; occupational hazards and core task requirements are clearly understood as well as responsibility is taken for the safe functioning of the whole system; safety is learning-driven. Many companies want to enhance their safety culture or some aspect of safety behaviour and to try to find enhanced ways forward. It is clear, that organization safety through technical design and management of physical or tangible resources/ assets, such as safer technology, regular audits and proper risk assessment; use of less hazardous chemicals and the elaboration of safe procedures, safety policies and guidelines, is relevant but obviously it is not enough. In the context of the management of OH&S, special attention should be given to intangible resources/ assets of an organisation, obtained through human OH&S experience and practice in the workplace. Safety knowledge can be conceptualised as an employees' understanding of the safety procedures (Hoffman and Morgeson, 1999). According to Edvinsson and Malone (1997) and Sveiby (1997), intangible assets of an organisation

consist of the immaterial sources of value related to employees' capabilities, competence, skills, organisational and safety culture, the company's image, an organisation' resources and way of action and the relationships. Workplace safety as a form of organisational expertise, which can be viewed as a situated practice, an emerging property of a social-technical system, the result of a collective process, a 'doing' which involves people, interaction, technologies as well as social relations (Gherardi and Nicolini, 2002). It is therefore situated in the system of on-going practices has both explicit (for instance, accident records, theories, safety regulations and guidelines etc.) and tacit (for example, safety engineer's experience, occupational hazard recognition, perceptual and cognitive skills) dimensions. When people solve complex problems in the field of OH&S, they bring knowledge, skills and experience to the situation, and as they engage in problem-solving they share their internal knowledge with others, so that tacit knowledge is converted into new tacit and explicit knowledge. According to Jacobson (2006), generally, knowledge sharing refers to exchange knowledge between members in organisation and focuses on human capital, whereas knowledge transfer focuses on structural capital and the transformation of individual knowledge to group or organisational knowledge, which becomes built into process, products and services. The process of knowledge sharing creates new knowledge inside the receiver, in the use, and sharing of tacit knowledge (Järvis and Tint, 2008).

Safety SC can be defined as an instantiated informal safety norm, assets and collective values that promote interaction and cooperation between members in organization in order to maintain an OH&S management system as well as to achieve the highest standards of occupational safety. Safety capital is "organizational knowledge embedded and created in the OSH (occupational health and safety) system – (it) is a long term asset into which OSH resources can be invested, with the expectation of an – uncertain – future flow of benefits in the form of gains in worker's protection and safety" (Nuñez and Villanueva, 2011, p 58). Rao (2007) pointed out that safety SC is urgent and indispensable to organization in order to create and sustain a positive safety culture. According to Nuñez and Villanueva (2011), the dynamic process of creation of safety capital (through combination and exchanging knowledge and skills in the field of OH&S, intervention) requires planning of resources, control and feedback systems in order to improve employees' learning and self-determination, effectiveness. The contribution of OH&S interventions to the components of safety capital consist: occupational risk assessment; competence and training; proactive hazard control and prevention; management of change; emergency preparedness and response; performance monitoring and measurement (Nuñez and Villanueva, 2011).

The authors argue that understanding safety knowledge development and transfer, particular those related to SC, is an essential in the field of OH&S. Although some researchers have investigated and pointed to the positive relation between human capital, reduction of accidents and good working relationship, for example in construction (Koh and Rowlinson, 2012), insufficient attention has been paid to the relationship between SC and safety culture as well as to KM in the field of OH&S performance; how SC manifests itself in SMEs. There is little known how employers and employees receive, analyse, share and use information and knowledge in the field of OH&S. Even though some researchers have proposed models and new concepts in KM in the field of OH&S (Podgorski, 2010; Rao, 2007; Sherehiy et al., 2006), there is no evidence about the applicability and roles of their models in the field of OH&S.

## 2. *MATERIALS AND METHODS*

Since OH&S is the multidisciplinary and complex field, some researchers (Clarke, 1998) have argued that safety culture cannot be completely understood through traditional quantitative methods, which attempt to break down a phenomenon in order to study its individual components. Safety culture therefore requires also the use of qualitative methods (Health and Safety Executive, 2005). Qualitative methods (content analysis, observation, interviews) are very often used as a starting point of investigation as they may help to develop conceptual frameworks. This research employed quantitative methods in order to explore employers' and employees' attitudes, perceptions toward OH&S, values, conflicts and relationships, information dissemination, risk awareness and employees involvement. In addition, qualitative methods were used in order to focus on a limited number of case studies and individuals, producing in-depth information, to investigate real safety situation in SMEs, with the intention to bring understanding to the concept of safety culture and real safety behaviour in investigated companies. Thus, a qualitative study approach allows studying the complexity of factors – they are related to workers, their behaviour and interactions with the safety management systems of the organisation. The substantive parts of the paper present recent comparative survey evidence from quantitative and qualitative safety survey.


### 2.1 Sample

A national questionnaire survey was carried out by Statistics Estonia in 2009. The objective was to gather information about psychological aspects of safety culture – how employers and employees feel, which attitudes they have and how they are value working environment, and environmental – what an organization has and does in the field of OH&S. Two questionnaires measuring safety attitudes, perceptions, values, conflicts and relationships, information dissemination, job satisfaction, responsibility and commitment, risk awareness, working conditions and safety measures were administered anonymously to employees and employers from SMEs from different branches of industry. The questionnaire also included additional items not relevant to the present research and article.

A special feature of the survey is that it is first linked data set of both employees and employers in SMEs exploring *inter alia* issues of employees' involvement, representation, responsibility for workplace safety and health, employers' commitment to safety; importance and relevance of the safety requirements and procedures, training and information; how safety is valued and appreciated throughout investigated organization. For the current article the survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. In the sample were correspondingly men (52%) and woman (48%). Approximately a half (54.2%) of the sample is less than 49 years old and 45.8% are 50 years old and more (Table 1).

Work experience is an important characteristic of this sample. A noteworthy 48% have worked at the same company for 1-5 years.  The higher response rate was from the organizations with less than 50 employees (Table 2). We found that companies with less than 250 employees to be more reluctant to respond to the questionnaire, which leads to a lower response rate from this type of firm.

Table 1. Distribution of sample data by age and work experience

| WORK EXPERIENCE, YEARS | No OF EMPLOYEES | SHARE, % |
|---|---|---|
| Less than 1 year | 27 | 1.5 |
| 1 to 5 years | 842 | 47.9 |
| 6 to10 years | 365 | 20.8 |
| 11 to 15 years | 241 | 13.7 |
| 16 to 20 years | 125 | 7.1 |
| More than 20 years | 157 | 8.9 |
| **TOTAL** | **1757** | **100** |
| EMPLOYEES' AGE, YEARS | No OF EMPLOYEES | SHARE, % |
| Less than 25 | 90 | 5.1 |
| Between 25 and 49 | 863 | 49.1 |
| More than 50 | 804 | 45.8 |
| **TOTAL** | **1757** | **100** |

Table 2. Distribution of Sample by activity, Size

| ACTIVITY SECTORS, Industry | POPULATION | RESPONSE RATE, % |
|---|---|---|
| Agriculture, forestry, fishing | 39 | 80.1 |
| Mining industry | 47 | 70.9 |
| Processing industry, textile-, chemical-, paper-, plastics-, wood-, metal industry | 49 | 58.9 |
| Electricity-, gas supplier | 40 | 71 |
| Water supply; sewerage; waste- and pollution treatment | 43 | 66.8 |
| Construction | 51 | 55.8 |
| Wholesale business, retail business. Machinery, vehicle reparation | 56 | 57.1 |
| Transport, warehousing | 32 | 56.6 |
| Other manufacturers | 27 | 55.8 |
| Health care, social assistance | 79 | 64.5 |
| **TOTAL COMPANIES** | **463** | **63.8** |
| SIZE (no. employees) | No OF COMPANIES | RESPONSE RATE, % |
| 5-9 | 150 | 27.6 |
| 10-49 | 197 | 34.9 |
| 50-249 | 110 | 19.5 |
| More than 250 | 6 | 18 |
| **TOTAL COMPANIES** | **463** | **100** |

## 2.2 Safety interviews with senior management and employees. Case studies

The case studies were intended to promote better understanding of the rationale of current safety culture in Estonian manufacturing SMEs, the development of needs, obstacles, and the changes that have occurred in the field of OH&S, particularly after Estonia became a member of EU. Results from qualitative studies by Järvis and Tint (2009 a, b, c) were used in order to complement and verify the results gained from safety survey. The exploratory study was based on workplace visits, semi-structured interviews with safety and senior managers as well as focus group interview with workers. Interviews were carried out in 8 selected enterprises from different branches of industry (the metal industry (3), textile industry (2), manufacture of devices and plastic processing industry (2), and printing industry (1), from various geographical parts in Estonia. There were carried out eight semi-structured face-to-face interviews with senior managers in charge of production operations, quality sections of their companies and eight interviews with safety managers. The study focused specifically on the perceptions of senior managers, exploring their attitudes, knowledge in OH&S, their commitment to safety, cooperation with OH&S specialist (occupational health physicians). The objective was to build up a picture which took into account not only how safety management is organized, implemented and maintained, but also how safety goals and practices are realised practically as an organizational value, how managers valued it, and how they viewed their role in improvement of safety culture. The interviews were conducted in Estonian and Russian languages. Each interview with managers lasted an average of 2 hours and was recorded. Interviews were then fully transcribed and analysed. All individual interviews with managers at enterprises were completed before the worker's' group interviews occurred. Data for this exploratory study were gathered from 8 focus group interviews with 22 industrial workers (13 males and 9 females). A simple random sample was selected from workers employed at the SMEs. The objective was to gather information about workers' attitudes and perceptions to OH&S, shared visions and values, safety practices, knowledge, and their involvement in safety management. Each focus group session lasted an average of 45 min and was recorded. Interviews were then fully transcribed and analysed. Every effort was made to protect the privacy, confidentiality, and anonymity of individuals and organizations participating in this study (Järvis and Tint, 2009a). The selected enterprises were SMEs (less than 250 workers), from different branches of industry. The enterprises were located in different parts of Estonia; however the majority were in or around the capital and western part of the country. The data from these enterprises were used for assessment the state of the safety culture as well as to examine problems specific to SMEs in the OH&S system. Relevant supplementary safety documents such as safety strategy, plan and instructions, risk assessment, safety rules and procedures, safety record, including incidents and accident investigation, meeting records were also carefully analysed in order to compliment and verify the data collected during the interviews. In addition, company's strategy, policy, values, vision - and mission statements were investigated based on the data available from their homepages.


## 2.2 Literature review
Active interest in OH&S requires that the workers and employers, OH&S professionals have the right information at the right time to make decisions affecting health and safety (Järvis and Tint, 2008). To support professionals, employers and employees, a good knowledge infrastructure is needed. According to Hugenholtz et al. (2007), knowledge infrastructure can be regarded as the sum of all sources and means

which is available to find relevant new knowledge for problems at hand. The process of knowledge transfer at the state level in Estonia was analysed in recent years (Järvis and Tint, 2008). According to the study results the main ways of knowledge transfer in the field of OH&S in Estonia are via CoP, the internet and training.

In order to investigate media and public attention to the OH&S, safety culture and SC in Estonia, a literature review was performed and newsletters and journals available for the period of 2009- January 2013 were analysed. A search was conducted via the Database of Estonian Articles Index Scriptorum Estoniae, which contains articles, from newspapers, magazines and journals, serial publications and anthologies and collections from the 1990s on, allowing the full-text to be accessed in free digital archives and Web publications. Key words: occupational health and safety, safety culture, occupational accident and disease, risk assessment, safety management, health promotion, conflict management, employees' involvement were searched and only the content of those articles related to health and safety were studied in Estonian, Russian, English and German languages.


*3. RESULTS*

**3.1 Companies Safety Response**
Case studies were performed in SMEs from different branches of industry. The enterprises were from different parts of Estonia, however majority were located in or around the capital and western part of the country. Methods which have been used as follow: safety walks, direct observation, risk assessment, safety documentation overview, safety rules and procedures scrutiny as well as in systematic interviews. Special attention was paid to ascertaining positive aspects expected from a prescriptive safety culture (based on Frazier et al, 2013; Meliá et al., 2012), such as: existence of a safety policy emphasizing safety values and actions in organization and shared between all employees; well-defined safety procedures and guidelines for all the operations integrated in work procedures; safety resources and investment; specific safety training and supervision; accidents and near-misses investigation; active employees' involvement in OH&S activities and health promotion. Company safety response refers to the state and process of safety. In detailed working environment and conditions in the investigated SMEs were analysed and presented in previous research (Järvis and Tint, 2009a,b,c; Järvis et al., 2010; Reinhold and Tint, 2013). In all the investigated Estonian enterprises written safety procedures for work operations and safety instructions were established. Most of the occupational hazards were assessed, evaluated and under the control. Noise, indoor climate and improper lighting conditions were identified as the main occupational hazards in the mechanical, plastic and printing industry. In addition, wood dust was the major problem in wood processing industry (Reinhold and Tint, 2013). Most of the investigated companies showed rather a positive attitude towards contributing to safety: developing safety practices and written work procedures, risk assessment, investigating occupational accidents, providing safety training for the employees. However, the main shortfalls of the OH&S system were discovered: the absence of a safety policy, poor quality of risk assessment, weak accident investigation and reporting procedures; the absence of near-miss reporting procedures. In addition, knowledge about OH&S was different in various enterprises. The authors identified insufficient safety training of new workers in 8 enterprises. During workplace visits and the interviews, gaps concerning how safety knowledge transferred were analysed. Some safety knowledge transfer barriers found in all investigated enterprises were

emphasised, such as lack of time and willingness to share information and expertise. Based on the case studies, it is possible to say that safety was not valued throughout all investigated companies due to lack of everyone's commitment to safety. Employees were not willing to talk about safety issues and they did not participate much in OH&S activities. Therefore strong safety communication problems exist in many enterprises (Järvis and Tint, 2009a; Järvis et al., 2010).

**3.2 Safety Survey**
**3.2.1. Organizational commitment to safety**
The substantive parts of the article present comparative survey evidence from the questionnaire safety survey of employers and employees. Visible commitment by senior management regarding safety includes interest, active participation and time for meetings, provision of resources for OH&S and Occupational Health Services (OHS) for employees; organization of risk assessment and accident investigation feedback, physical presence in the workplace, participating and supporting OH&S training, involvement employees in OH&S activities. The results of 5 items about organizational commitment to safety (See Table 3) give an overview of the general results. All items give a positive view of senior management commitment and show that safety is given high priority by the management. Safety survey shows that safety is considered as a real interest for the organizations in Estonian SMEs, even more important than production, receiving business objectives and investment. To the question about the main motivation to deal with OH&S issues, 43% of employers stated that the employees' health protection, followed by compliance with law and regulations were the main reasons for managing OH&S.

Table 3 Items related to company commitment (employers' responses)

| Items | N | Employers, % |
|---|---|---|
| This company deals with OH&S in order to provide for employees' health protection | 199 | 43 |
| This company worries about safety because it is required by Law | 144 | 31 |
| Safety is important in order to enhance efficiency and productivity through the prevention and reduction health problems | 93 | 20 |
| Safety is essential for increasing employees' motivation | 13 | 3 |
| This company worries about safety as a matter of public image and good reputation | 9 | 2 |
| Do not deal with OH&S | 5 | 1 |
| Total | 463 | 100 |

In response to the question about the 'most important considerations as an employer', 96% of respondents reported that good and safe working conditions, employee job security (94%), motivating payment (89%) are the most essential reasons. In addition, work organization according employees' desires and needs (74%); employees' independence and the right to make decisions (73%), as well as close supervision and controlling of employees (66%) were also mentioned as factors. When asked to rate OH&S in terms of importance on a scale of 1 to 5 (where 5 is very important), along with other workplace issues, employers and employees place greater importance on safe working conditions, employees' awareness about the organization's activity and work organization, good relationships and job security issues as the most important aspects in working life. Employees rate motivating payment as the second important workplace issue (96%). Both, for employees and employers on the other hand, work by itself and possibility for development were much further down the scale. They rated highly issues such as job security, good relationships between employer and employees, the balance between work and home life; employees involvement in decision making process regarding work organization and working conditions. Employees and employers both rate an interesting job, career and opportunity for employee development as the less important factors in working life (See Figure 3).
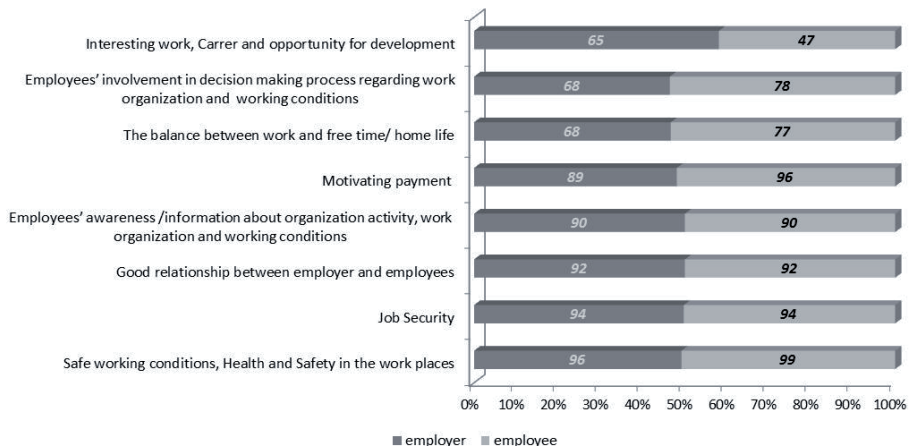


Figure 3. Importance of different aspects of working life. (Question: Q: Please tell how important is each aspect for you ..?)

Employees and employers share common perceptions of responsibility for managing OH&S and thought that this is 'everyone's responsibility', which in a positive sign related to safety culture. 81% of employers and 76% of employees considered that they are equally responsible for the OH&S and only 14% of employers and 16% of employees identify health and safety issues as being the primary responsibility of the employer and only a minority of respondents (6 %) feel the individual employee is liable for controlling risks. To the question to employers about who is actually dealing with OH&S in the organization, a majority of employers (85%) said that they are dealing with this themselves, half (54%) of employers report that they also had a safety manager and safety council (17%) in dealing with OH&S. At the same time, the qualitative survey data revealed that traditionally in all investigated companies, this task is delegated to the safety managers, human resource managers or, even to accountants (Järvis and Tint, 2009a).

13

### 3.2.2. Working conditions, employers' and workers' perceptions of safety

The vast majority of the employees (66%) and employers (77%) feel that they work in a safe environment. However, 15% of employees and 22% of employers could not identify how safe their working environment is. Employees (18%) are more likely to consider the workplace risky than their employers (9%) who actually have formal responsibility for OH&S within their organizations. Most of the employers tend to underestimate risk and do not believe that their employees are exposed to any dangerous occupational risk. The results from the current survey are in line with Woolfson et al. (2008) and Alvensson (2004) who demonstrated that safety management is still inadequate, especially in SMEs, due to time constraint and lack of knowledge. Employers and employees showed a good awareness about possible risks in their work places. When asked in detail about specific common occupational hazards of the workplace, employers and employees mention broadly the same issues, but they perceived occupational safety risks differently (See Figure 4). Employers listed more occupational risks exist in their organization, such as ergonomics related to work with computer (81%), risks in use of machinery and electrical devices (53%), and manual handling of heavy loads (73%). Employees reported that repetitive movement (57%), inappropriate microclimate (extremes of temperature) (46%), noise (38%) followed by poor lighting (24%) are the most important hazards within the workplace.
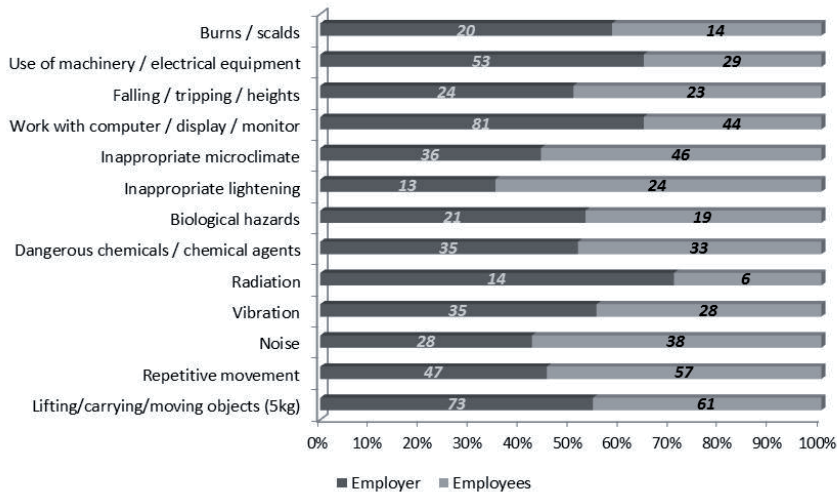


Figure 4. Factors which present a problem in your workplace?

To make a relative assessment of safety measures, employers and employees have a similar hierarchy of concerns; in particular, two main prevention measures (proper and safety task performance and work organization according to employees' capabilities) appear to be applied in majority of SMEs. The employers and employees responses demonstrated a relatively good awareness about different safety measures. The questionnaire enables us to analyse the practices of prevention and the intervention activities used in the companies investigated. Case studies demonstrate that daily OH&S management activities applied in the investigated companies were

14

equipment maintenance, inspection of premises, provision of personal protective equipment, risk assessment (evaluation occupational hazards). However, although risk assessment was performed in all investigated 8 companies, the authors identified some shortages in quality of risk assessment and efficiency of safety measures (Järvis et al., 2010).

Next, authors address the central issue of employees' involvement and encouragement in OH&S activities.


### 3.2.3. Employees' involvement and workplace relations

The relevant Estonian legislation and the European Framework Directive on OH&S require that all employees and their representatives be informed of the risks to their health and of the safety measures required. Generally, information and representational channels via individual safety representatives takes place in smaller enterprises, while (indirect) via elected representatives meeting together with employer representatives' in health and safety committees occurs in larger enterprises (Woolfson et al., 2008). According to Estonian legislation, safety council is legally mandated in enterprises of more than 50 employees. In the investigated SMEs, more than half of employers (51%) and only 43% of employees reported that safety and health workers' representative is elected in their organization. The questionnaire study reveals that, for employers (40%) and employees (50%), it is very essential that employees be informed about organization activity, work organization and working conditions. However, only 17% of employees were very satisfied with amount of provided information about these issues. Safety culture presumes effective communication and employees' safety participation and involvement in OH&S activities. While around all, employees (91%) stated that there is vital for them to be able suggest and be involved in decision-making process concerning work organization, training, payment, safety and working conditions, 53% of employees reported that they cannot give their opinion in training and further training, and 30% reported they cannot manifest their opinion in any of the topics. There are some aspects which are more important for employees than for employers, for instance: to be involved and participate in decision-making processes (correspondingly, 33% employees and 14% employers), to be informed about general organization activity and work organization as well as about working conditions (50% employees and 40% employers); while employees (64%) value job stability more than employers (43%).

Although, for more than a half of employees (77%) good relationships are very important in organization, only 2% of employees stated that they have a 'very good' and 50% 'rather good' relationship with colleagues while 42% of employees reported a very good relationship with their employer. There is potential for the occurrence of conflict. However, only 22% of employers declared that conflicts with employees took place, 98% of employees reported that they never had any conflicts with their employers. From these results, it is possible to conclude that conflicts might exist and are more likely between co-workers than between employees and employer. This can be also one reason for dissatisfaction of employees with their relationships at work. According to employers' opinion, there are three main causes of conflict in the workplace: noncompliance with the duties and agreements, poor information transfer and employee absenteeism. Additional possible work-related causes of the conflict have not been investigated. Employers (65%) said that the main methods used in order to solve problems are discussion with employees and reprimand. There is a contradiction of results however, because only 9% of employees reported that they discuss the problem with employers in order to solve the conflicts. Virovere, et al.

(2001) identified similar factors in separate articles on workplace conflict in 2001: lack of provided information, a lack of teamwork as well as unclear work procedures and rules.

### 3.2.4. Ability to learn

The ability to learn is central for enhancing safety culture through a continuous learning process, which requires transfer and exchange the information. It involves the organization's ability to recognize problems related to OH&S, to implement solutions, and to monitor the effects of the solutions, provide feedback. According to results from our questionnaire, employees are generally content with the amount of OH&S information and training they receive. 80% of employees said that amount of OH&S information they receive from their current employer was 'enough', and half of respondents (51%) feel their safety training also to be 'very or rather sufficient' (See Figure 5). However, only 30% of employees stated that they have a possibility to continuously complement and improve their knowledge, while only 29% of employees used such opportunities and participated in relevant training, 24% attending conferences and courses during the last 12 months. Only 35% of employees feel that they do not have any possibility for training and receiving new information in their organization. On the other hand, only 10% of employees were very satisfied with opportunities for development, and 12 % with possibilities for receiving new knowledge. At the same time, half of the respondents (50%) stated that the possibilities for training and receiving new information, as well as opportunities for development at work, are limited. One third of the employees (35%) reported that their job does not require any creativity and new knowledge.
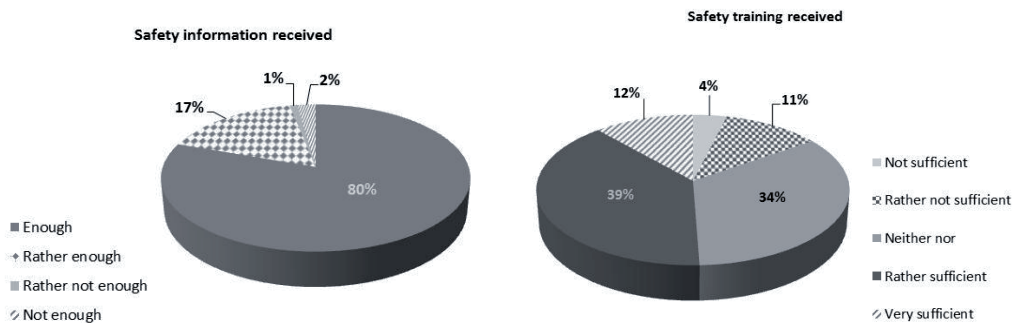


Figure 5. Safety information and training available in organization (Questions: "Do you think the amount of information you receive from your current employer about OH&S issues is ..?" and "Do you think the amount of safety training you receive from your current employer is..?"

Since in 2009 there was a difficult economic situation in Estonia, it is possible to conclude that at that time, to keep a job was much more important for the employees. The safety survey demonstrates that majority of employers (87%) evaluated the level of knowledge of employees who are dealing with OH&S in organization as very or rather good and sufficient. According the responses received from the employers, from the personnel responsible for OH&S workers (72%) participated in OH&S training and conferences during the last 12 months and more than a half of employers (55%) said, that responsible workers also exchange the OH&S information with other enterprises, while 54% receive relevant information from the labour inspectorate. The main sources of OH&S information are professional literature (94%), published

guidelines and regulations (93%). The questionnaire survey enables us to examine the level of knowledge and amount of training received in the field of OH&S by employers. However, qualitative survey evidence indicates that employers in Estonian SMEs do not receive any special safety training. Respondents were also asked to identify from which sources they generally receive OH&S information. A total of 89% of employees reported that they receive OH&S information from their employer or supervisor. This result is in line with research carried out in three Baltic countries (Estonian, Latvia and Lithuania) by Woolfson et al (2008). Employers (82%) also declared that OH&S information was generally provided by employer or supervisor. However, according to present questionnaire, only 4% of employees and 6% of employers stated that generally employees received OH&S information from workers' safety representatives.

### 3.3 Main findings from safety interviews

The results from the interviews with senior managers and employees are presented in Järvis and Tint (2009a). Our results coming from the content of the safety interviews show similar results to those obtained by the questionnaire study and also make it possible to indicate and identify important safety flaws:

- The management of health and safety hazards at work is not included in management practice, corporate risk management or strategic management.
- There is a lack of management awareness and commitment to safety. It has to be highlighted that only one of the interviewed managers usually participates in safety meetings (Järvis and Tint, 2009a). Seven of eight interviewed senior managers did not receive any safety training.
- Employers considered working environment in their enterprise as safe (Järvis and Tint, 2009a, b). In all investigated enterprises written safety guidelines and procedures exist, but their fulfilment was not periodically updated and monitored. However, written safety guidelines and rules do not guarantee that employees understand all information and thus will be able to foresee all risks in their working environment.
- In four companies, there was a lack of real safety talks and cooperation between some supervisors and their workers. In three companies, employers and employees stated that they accept unsafe behaviour of employees in order to accomplish production goals, and even, willing to compromise on safety for increasing production. In addition, the authors evaluated unsuitable programme of work and an unrealistic daily required working load, which is impossible to achieve during the shift. This is unacceptable from the safety point of view as well as from labour rights and decreases employees' motivation.
- In some companies there were established a formal but not used safety programs, like a strictly formal use of preventive observations and audit. Unsafe jobs, supervisors' and employees' unsafe behaviour (working without safety devices)
- Interviewed employees said that they have all necessary technical and personal protective equipment and they were provided with OHS. At the same time, employees said that senior managers do not show interest in the safety of workers and do not participate in safety meetings and there is no information available about discussions of OH&S issues at the top management level. One employee said: *"Generally we do not discuss OH&S issues with my colleagues. According to my opinion, all the system (training, risk assessment*

*etc.) in our enterprise is formal and exists just on paper..* " (Järvis and Tint, 2009a)

- Insufficient and formal safety training provided for employees, especially for the new employees. There are several gaps of safety knowledge transfer (Järvis and Tint, 2009a, b).

Many of these flaws were checked during the observation and documentation analysis as well as in several interviews.

Fear of litigation does not come out as a major concern in the survey. All interviewed managers stated that the need to meet legislation and maintain good profit is main reason why organisations are taking OH&S management seriously. To the question about need to maintain a good business and a positive reputation in the community, media and industry, six of eight managers suggested that they do not much worry about it, because OH&S issue does not attract media attention in Estonia. These results were confirmed by public media survey carried out by the authors in 2002-2009 (Järvis and Tint, 2009a) and 2009-2013.

### 3.3.1. Company's homepage analysis

The authors carried out textual content analysis of the homepages of the eight investigated companies in order to examine how organizational vision, strategy, mission and values reflect and express commitment to safety and safety culture. In addition, twenty randomly chosen company homepages of SMEs from different branches of industry were also investigated. Altogether, eleven companies' homepages contain issues related to OH&S and two were companies included in case studies. The example of the statement available from homepage: "health and safety goals are highly appraised and paramount, we ensure that employees will be informed about whether and how health and safety goals have achieved".

In order to get comparison data, the authors randomly chose twenty five industrial SMEs of the most competitive fifty enterprises from the Estonian Companies' Competitiveness Ranking 2012. Together, 309 companies were compared against each other in the category "The Most Competitive Small and Medium-Sized Enterprise" and "The Most Diversely Competitive Company" whose competitiveness is simultaneously based on its size, dynamism (speed of development) as well as efficiency (Estonian best enterprises, 2012). The objective of the homepages analysis was to evaluate how important OH&S was for those companies and how essential a factor its promotion/ advocacy is for the companies' competitiveness in Estonia. Survey results show, that topics related to OH&S were mentioned only in three companies' homepages of the investigated twenty five companies. For instance, one statement as follows: "We recognize the importance of the improvement of working environment and occupational safety".

It is impossible to make any conclusions about the attention devoted to safety inside the investigated companies, the presence or absence of safety culture or poor safety. However, it is possible to surmise that OH&S is not a company's core issue and safety is not considered as a vital factor for promotion/ advocacy in the companies' homepages as one part of the company identity.

### 3.3.2. National media analysis

This chapter is based on text content analysis. The authors draw on a strategic overview of publicly available documents, e.g. newspaper articles, articles from trade unions, magazines. The literature survey shows, that topics related to occupational

accidents and incidents, safe working environment, good industrial relationship and conflict management, workers' health, SC and leadership were mentioned only in 3 to 21 articles published between 2009-January 2013. Altogether in 2009-2013, 261 articles about the topic 'occupational health' were published (215 articles in journals, 42 in newspapers and 4 in collections) and 160 on 'occupational safety' (112 articles in journals, 46 in newspapers and 2 in collections) as well as 75 about 'occupational accidents' (42 in journals and 33 in newspapers). There was no publication found in 2009-2013 about 'safety culture', 'occupational health services', 'personal protective equipment', 'occupational hazards'. The number of mentions of such topics in media is small, for instance, an article on topic 'strategic management' more than 1100 articles were found, but they do not include OH&S issues, and only 22 include issues of knowledge management.

OH&S management as on part on management was also a neglected topic in the media. It is interesting that 'safe behaviour' was published in 34 publications, however 'ethical behaviour' which also should mean and include fulfilment and implementing of safety requirements and rules, was not mentioned in any publication. At the same time, the issue of 'ethical management' was published in 1152 publications. This can be explained based on the relevant situation in Estonia. Many organizations were under focus of media scrutiny because of a series of political and financial scandals, like unethical and corrupt behaviour as well as illegal use of finance, investments, financing of the election campaign of a political party, unethical providers of finance (Kerner, 2010; Meikar, 2012; Toots, 2012). Aspects like ethics, ethical behaviour, values and corruption received much attention in public media. According to the literature survey conducted on the topics of 'employee involvement' (368 articles), 'employees participation' (341 articles) these topics were less important for employers in 2009 as well as interesting for publication purposes, as authors expected. There were found 1671 publications about 'working environment', however only 3 of them contained term 'safe working environment' and 20 of them were related to 'risk assessment'. This result is in a line with employers' and employees' opinions from the interview, that subject of safety and safe working environment does not attract media interest in Estonia.

Mass media could play an essential role when planning the health and safety information dissemination for the general public and for raising employees and employers' awareness. This would imply a media re-focus towards what really matters (Moen et al., 2010). In addition, national media can offer added-value presenting, discussing and analysing various opinions of practitioners, experts, trade unions and employers' federations, highlighting causes and consequences of the occupational accidents and incidents. There can be an essential contribution of national journals, reports, websites that contain publications and also contains access to scientific publications on safety culture, SC; OH&S issues. One of the most effective channels is a regularly published newsletters and journals where OH&S issues are widely and extensively dealt with (Järvis and Tint, 2008, 2009a). However, the professional journal 'Estonian Newsletter on Occupational Health and Safety', which was the main national journal and channel for regular dissemination of information and knowledge in order to support professionals and provide valid, up-to date and relevant information, was closed in 2010. Since that time, there is little information available for OH&S professionals at a local level in Estonia.

*DISCUSSION*

The results of the current study contribute important empirical evidence on how small and medium business worksites address OH&S. Although significant progress has been made in the field of OH&S, there are still challenges ahead.

Results from the questionnaire survey revealed that employees evaluated positively all aspects of work, such as: general management practice, job satisfaction and work organization. However, employees' involvement in different activities in organization was limited and weak. While, SC requires collective activities, networks, cooperation, active employees' involvement and commitment, the results from the current survey showed a lack of SC in SMEs in Estonia.

Analysis of the safety culture questionnaires shows many SMEs with an outstanding safety culture and positive safety attitudes. Safety training, safety work procedures, relevant information provision, communication and supervision – all important aspects of the organizational life are viewed from the OH&S perspective and were positive, which Meliá et al. (2012) called 'prescriptive safety culture'. In order to explore and verify the 'real' situation in SMEs, direct case studies and interviews were conducted. Qualitative approaches to safety assessment, provided by safety interviews, observation and documentation analysis indicate some important safety flaws. The authors would like to emphasise that the results from the quantitative and qualitative research cannot be generalized to other SMEs and play an illustrative role.

The study reveals essential aspects which should be considered in process of evaluation of safety culture, like organizational, human and social perspectives in safety. It is clear, that a quantitative approach using a reliable and valid tested questionnaire can provide an overview of the safety climate (employees' perception and attitudes) and an overall safety organizational picture. However, safety documentation and questionnaires tend to reflect only 'formal' procedures in the organization. It is not enough in order to understand the 'real' state of the safety, procedures, the shared and active values and beliefs that guide behaviour patterns and OH&S activities in the organization. Therefore, integrated approaches should be used, which allow employees and employers to declare and reflect some important safety flaws.

In order to avoid an 'illusion of safety', it is vital to focus less on paperwork (formal safety rules) and more on implementing organizational structures which allow for managers and employees to interact and cooperate, to learn from safety practice and experience. The authors take the community of practice (CoP) as a source of safety culture and as the privileged focus of learning and transmitting practical safety knowledge. To do so, managers must spend time in CoP and build trust among the members, which is vital for the opportunity to convert tacit knowledge into explicit shared knowledge. Therefore, CoP can provide a possibility for learning, sharing values among members of the CoP, through which organization can grow and develop new intellectual capital.

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**Appendix 6.**

**Research paper VI**

Järvis, M., Virovere, A., Tint, P. (2013). Knowledge Management: a neglected dimension in discourse on safety management and safety culture – evidence from Estonia. *Scientific Journal of Riga Technical University* (forthcoming, ETIS 1.2)

# Knowledge Management – a neglected dimension in discourse on safety management and safety culture – evidence from Estonia

Marina Järvis1, Anu Virovere 2, Piia Tint 3, 1-3 *Tallinn University of Technology*

*Abstract* – The current study proposes a model for a positive safety culture with a knowledge management dimension and tests this on a sample of 1757 employees from Estonian SMEs in different branches of industry, using the factor analysis. Despite conceptual and empirical justification, researchers have not consistently included concepts of knowledge management in safety culture studies. This paper explores the possibility of using Knowledge Management in the Occupational Health and Safety Management System. The paper reports on an empirical examination of the relationship between safety climate and safety culture through a knowledge management dimension with a special focus on the management of safety knowledge. The results of this study indicate that safety climate has impact on the three dimensions of safety culture, namely psychological, behavioral and organizational aspects of safety culture. This paper supplements Cooper's Reciprocal Model of Safety Culture with Knowledge Management System Dimensions. Several specific features of knowledge management, such as communication, personal competence and responsibility, were found to influence the relationship between safety climate and safety culture. Thus, an effective assessment tool for the evaluation of knowledge management dimensions of safety culture could be proposed based on the results of this study.

*Keywords* – Safety culture, Safety Climate, Safety Assessment tool, Knowledge Management, Organizational Values.

## I. INTRODUCTION

Occupational health and safety (OH&S) has attracted much interest through the years for economical and ethical reasons, but the ways of approaching the problem have changed [1]. Interest in evidence on the economic aspects of OH&S is growing. Recent studies have revealed that occupational safety as a part of enterprise's business strategy helps to decrease accidents, illnesses, reduce absenteeism, turnover rates and increase profits and productivity, and create jobs [2; 3].

Safety through controlling the physical aspects and technical hazards is still entirely relevant to ensuring safe and healthy work systems, but in itself it is now regarded as insufficient in order to reduce accidents. As a part of safety management system (SMs), it is important to focus on managerial and organizational factors as well as to understand the human contribution to major accidents and disasters. Attention in recent years has shifted towards better understanding of the psychological and social preconditions for worker's unsafe behavior and accident causation. Researchers and practitioners have shown increasing interest in safety culture and in the possibilities

to maintain and improve it because of its impact on safety outcomes such as occupational accidents and fatalities, safety behaviors [4; 5; 6; 7], absenteeism, productivity, work methods, quality, commitment, loyalty and work satisfaction [8; 9]. Safety behavior is also one of the main issues (together with situations and person factors) identified in the model of safety culture as the key factor which is applicable to the accident causation chain at all levels of an organization [8; 10]. Positive safety culture requires not only stronger institutional pressure [9], a change of mentality and an authentic commitment from organizations [5], where all employees and the employer commit and participate in health and safety activities, but also relevant organizational structure in order to share values and practical safety knowledge. In addition, the positive cultures require special organizational structure which will enable people communicate directly and, thus, exchange (tacit and explicit) knowledge as well as collective learning [11]. Safety knowledge can be conceptualized as an employees' understanding of the safety procedures [12]. According to some researchers [13; 14], intangible assets of an organization consist of the immaterial sources of value related to employees' capabilities, competence, skills, organizational and safety culture, the company's image, an organization's resources and way of action and the relationships.

Despite the growing interest in Knowledge Management (KM) studies, only a few studies [15-18] have been conduced in the field of OH&S. There is potential for organizations to learn, adopt and apply best practice, knowledge and information in the area of OH&S from other companies and various state authorities [19]. As such, this study investigates how safety knowledge is managed as an antecedent of safety culture.

This article examines relationships between safety climate and safety culture, presents and discusses a possible innovative conceptual model for the improvement of safety culture consisting of KM dimensions that incorporate both tacit and explicit safety knowledge and understandings based upon 'Communities of Practice (CoP)'. The authors emphasize the importance of CoP as sources of safety culture and as the 'one important focus' of learning, transmitting practical safety knowledge as well as sharing values among members of the CoP, through which an organization can grow, learn and develop new intellectual capital.

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This article concerns organizational safety culture and the structure or architecture of employees' attitudes to safety as part of that culture, as well as the ability to learn, which also should mean changes in workers' behavior in order to enhance safety culture. First, the authors define the safety culture and safety climate and review the modified Cooper's model of safety culture with KM aspects. Section 2 outlines the methods used in the research. The last section presents results, an analytical overview and discussion of overall safety culture in Estonian manufacturing small and medium-sized enterprises (SMEs). The authors hope that the presented evidence-based model will help to design an interactive learning environment and effective safety training and learning possibilities to support knowledge-management activities in the organization.

*Safety Culture and Safety Climate*

The term 'safety climate' had appeared several years earlier than safety culture in an investigation of safety attitudes in Israeli manufacturing [20]. Since that time, both terms are widely used and differently defined by researchers [6; 21; 22]. According to Flin, the most widely accepted definition of safety culture is from the nuclear power industry: "the safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's SMs [23].

According to Zohar, safety climate is a summary of "perceptions that employees share about their work environment" [20, p 96]. Safety climate can also be defined as the perceived state of safety of a particular place at a particular time [24; 25]. It is therefore relatively unstable and subject to change depending on the features of the operating environment. Later on, Zohar suggested that safety climate relates to shared perceptions with regard to safety policies procedures and practice [26]. Wiegmann with colleagues stated that although literature has not presented a generally accepted definition of safety climate, it is possible to identify commonalities with safety culture, such as: safety climate is a psychological phenomenon, sensitive to state of safety at a particular time and closely concerned with intangible issues such as situational and environmental factors as well as being a temporal phenomenon, a 'snapshot' of safety culture, relatively instable and subject to change [22, p 124].

It is possible to say that safety culture is expressed through the safety climate in an organization. Previous collaborative research by the authors has shown empirically that many managers have started showing an interest in safety performance and their conclusion is that intervention should be directed towards workers and worker behavior [27; 28]. A safety culture (a sub-unit of organizational culture) does not have a unique and universal definition [4]. However, it can be defined as the product of the individual and group values, attitudes, beliefs, risk-perceptions [29], competencies, norms, principles, and patterns of behavior that determine the commitment of employees to health and safety, as well as the style and proficiency of an organization's health and safety programmes [30].

*Model of Safety Culture and Knowledge Management Aspects*

Safety as a form of organizational expertise is therefore situated in the system of on-going practices that has both explicit and tacit dimensions. Safety knowledge can be conceptualized as an employees' understanding of the safety procedures [12]. KM has become an important process in knowledge intensive companies over the past few years, focusing on assessment, creation, transfer, and utilization of knowledge to address specific challenges [19]. From the organizations' point of view, one of the key ways to increase the efficiency of safety knowledge exchange is to develop an appropriate organizational structure as well as new and more flexible ways of working.

Existing models of Safety Culture are described and analyzed in depth in previous research [31]. Reviews of safety culture surveys identified some common aspects, for instance: management concern and commitment, personal responsibility, peer support for safety, employees' involvement in health and safety activities, and the SMs [4; 21; 24]. According to Cooper's model, the concept of safety culture contains three elements, which are related to people, their behavior and their interaction with the safety management system within an organization: internal psychological factors (safety climate), external observable factors – organization (SMs) and job (Safety behavior) (see Fig. 1) [8]. In addition, all the elements of this model can also be broken into exactly the same reciprocal relation-ships, thereby allowing the multi-faceted nature of the safety culture construct to be systematically evaluated.

Other researchers [6; 32] have also proposed models to illuminate the concept of safety culture. The main and only difference between Geller's model and Cooper's model is that the term environment is used in the former model while the term situation is used instead in the latter model [9]. The dynamic and interactive relationships between persons, environment and behavior were proposed in a "Total Safety Culture" model by Geller, which estimates 10 core values for the attainment of a total safety culture [32]. The safety culture model presented by Choudhry with colleagues [6] was based on Geller's model and on Cooper's model in the context of the construction industry, with the distinction that the construct environment in Geller's model and situational in Cooper's model are incorporated into a new construct – situation/ environment - in order to reflect not only the situational aspects of the organization but also the specific conditions of the construction project. Empirical examination of the relationship between safety climate and safety culture on construction sites was also performed by Teo & Feng [9] and the model was proposed to describe the relationship between safety climate and the overall safety culture in construction organizations.

Although the dissemination of safety information and knowledge are important aspects for effective and successful managing health and safety in the organization, little attention has been paid to the process of safety knowledge exchange. In order to fill this gap in the literature, based on previous empirical research and literature review, Järvis & Tint [31] proposed a new reciprocal safety culture model with a new construct – 'communities of practice' - shared knowledge in order to reflect not only specific organizational (situational/ environmental), behavioral and psychological aspects of safety culture, but also include knowledge management aspects that incorporate both tacit and explicit safety knowledge and understandings. Thus, the concept of CoP is important in addressing not merely employee behaviors, practices and norms, but simultaneously the role of management within the organization in providing a facilitating and enabling climate of safety through which safety cultures can be embedded in organizational practice.
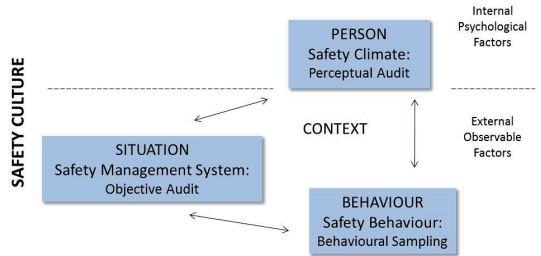


Fig. 1. Reciprocal safety culture model [8]

The focus on the continuous two-way flow of influences, vertically within the organization, is complemented by the attempt in the CoP approach to capture that horizontal dimension of knowledge management is not exclusively in the possession of management, but generated in day-to-day practices of task-based tacit understandings of good safety behaviors by employees themselves at all levels within the organization. This model is based on Cooper's [8] Reciprocal Safety Culture Model, with added Knowledge Management Dimension, which can allow in-depth study of the impact of Knowledge Management on the development of safety culture processes (see Fig. 2).
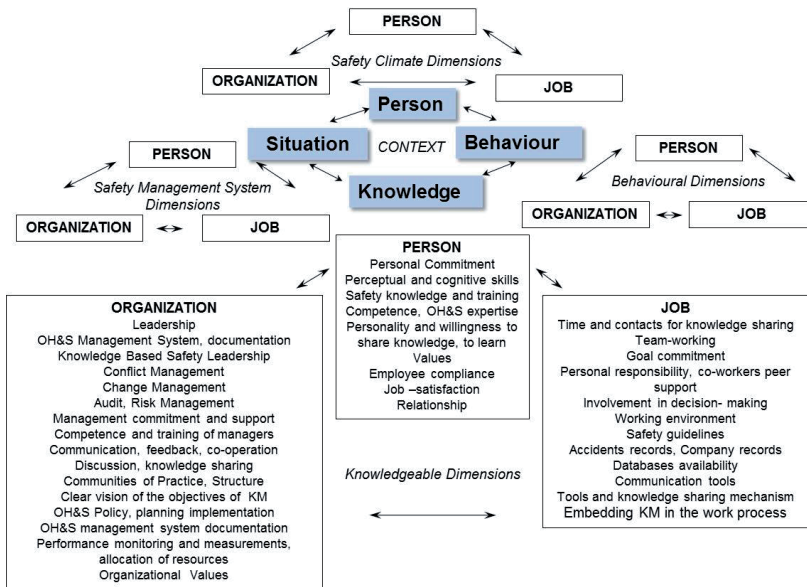


Fig. 2. Reciprocal safety culture model [31]

The model proposed takes into account the dynamic interrelationships between safety climate, SMs, safety behavior and motivational strategies for safety knowledge exchange within a CoP at the enterprise level. Thus, the authors suggest that organizations should pay more attention to how their safety knowledge is managed (how knowledge created, transferred, exchanged and used by employees) in order to develop a positive safety culture and to change employees' safety behavior. The suggested knowledge elements of the model can also be broken down into exactly

3

the same reciprocal relationship. Presented reciprocal model provides a comprehensive way of thinking about the many processes and aspects that might impact safety culture with respect to the managing of safety knowledge. The concept of the presented model is also partly related to Reason's (1997) "informed (or safety) culture" model, which includes dimensions of an informed, a reporting, a flexible and a learning culture [33]. An informed culture (equivalent to a safety culture) comprises many types of situational specific cultures (not all of which are safety related), which interact with each other to create the "informed culture". Reason's approach can also be subsumed within the psychological, behavioral and situational components of the reciprocal model [8].

The following section provides an overview of the main core constructs of the proposed safety culture model which were tested in the current study. Some constructs reviewed below have never been included in a published survey of safety culture, but have potential to offer meaningful value to safety culture measurement. As organizational (situation/ environmental) aspects of safety culture, the current study focuses on constructs as follows:

*Management concern for safety:* The most common construct in safety culture survey is the perception of leadership and management/supervisors' attitudes and behaviors around safety [24; 34]. According to Frazier [4] and Teo & Feng [9], management should encourage safe behavior of employees. Like previous research [35], this study suggests leadership (management and supervisors) should spend more time on the floor with employees and build trust, which is vital for the opportunity to convert tacit knowledge into explicit shared knowledge. Management commitment also can be demonstrated by allocation of the resources in the field of OH&S.

*Relationships and Conflict Management:* There is no survey previously reviewed of conflict management as a learning instrument and its possible effect on safety knowledge exchange. Thus, this study expands on a key gap in the literature by including this factor. The current study investigates relationships between employers and employees as well as co-workers, possible conflicts, possible conflict solutions strategies. Relationships also include promoting positive working, seeking to avoid conflict and dealing with unacceptable behavior [36].

Traditionally, conflict has been regarded as abhorrent in organizations. Mullins stated that a healthy organizational climate should reflect only complete harmony. However, this view (espoused in [37]) is no longer paramount. Conflict can be a positive force that stimulates creativity and interest, and can assist in resolving problems and promotes group cohesion [37]. It can also be a stimulus for organizational learning [38]. At the same time, conflict has been found to be a useful research tool revealing an organization's general status as a status indicator [39]. Rahim [40] suggests that conflict analyses would provide information about employees' work satisfaction and motivation, flow of information and knowledge and thus, learning as well as overall climate on the

organization. The essential aspect is that conflict, like most culturally-based things, must be recognized, acknowledged and be managed.

*Communication, knowledge sharing, Communities of Practice:* Organizational learning is a process whereby organizations share, create, spread, and expand their knowledge [41]. This is also a tool for the development of a CoP and potentially gives a possibility for employees to exchange explicit and tacit knowledge. Explicit knowledge, sometimes referred to as codified knowledge, is objective knowledge that can be transmitted in formal, systematic language [42]. An example of explicit knowledge on OH&S consists of governmental and local regulations, standards, norms, and safety requirements, which are stored as written documents or procedures. In the context of the management of OH&S, special attention should be given to tacit knowledge, because the research topics are often identified through direct human experience in the workplace, and the results of the research are often immediately applicable to the solution of a problem. Examples of tacit knowledge are: safety engineer's experience, safety hazard recognition, perceptual and cognitive skills, physical experiences, rules of thumb and synthesis of facts [16]. In order to exchange explicit and tacit knowledge, there is a need for a suitable organizational structure where cooperation, teamwork and verbal communication are available and adopted [11] and for good safety climate to be created for informal exchange of safety knowledge.

According to Hislop [43], CoP is realized in informal groups of people who have a particular activity in common, and as a consequence have some common values, knowledge, and a sense of community identity. Generally, information and representational channels via individual safety representatives take place in smaller enterprises, while (indirect) via elected representatives meetings together with employer representatives' in health and safety committees occur in larger enterprises [44]. Health and safety committees have the ability to create knowledge assets that are relevant in terms of OH&S at the workplaces, and thus can be viewed as a channel for knowledge creation [45]. In addition, the study [45] emphasized such essential factors as management commitment, scope and content of training of health and safety committees' members and provided resources.

The authors argue that the health and safety committees could act as a CoP, but their contribution for shaping safety culture and exchanging knowledge and, thus organizational learning, is not enough, because of the small number of employees involved and lack of management commitment.

Communication, participation in decision-making, sharing valuable knowledge and sharing attitudes and view-points [46], employees' involvement in processes, as well as social good relationships and conflict management are essential factors that promote trust and effective communication. Trust could be achieved through the involvement of employees in decision-making [47], having credible communication and good relationships, based on organizational values.

In the context of organizational change, attitudes to change become an important issue. Organizational learning can be defined as a vital process by which organizations adapt to change [47]. The ability to adopt to change is enhanced through learning, both individual and organizational levels. According to Alas [47] and Robertson & Cooper [36], it is essential to provide information of how organizational change is managed and communicated in the organization.

*Safety Management Systems:* According to Flin with colleagues [24], safety systems involve a mix of the formal audit processes and organizational procedures that managers use to manage safety, for instance: establishing safety committees [20], developing prevention strategies. Frazier with colleagues [4] stated that the concept of existing SMs is essential when assessing safety culture. Based on [4; 5; 9; 21; 24; 48], the current research reviewed factors which an effective SMS should contain, for instance: safety policy procedures and rules; incentives for employees' participation and employees' engagement, provided safety training, communication, planning, control, safety audits. Below we expand upon what we see as the key dimensions which enable the full scope of CoP to be explored empirically.

*Organizational Values:* A person's ethics and beliefs are clearly shown in their values. The values of the senior managers create a basis for trust and the organizations' credibility, so long as those values are seen as 'core' and 'intrinsic' to management behaviors [49]. Safety culture can be defined as a product of the individual and group values, attitudes, beliefs, risk-perceptions [29]. Therefore, it is also essential to evaluate safety as a value in the organization (what can be called "safety values in use" [50]). If employees feel that they are an important part of the organization and they perceive the high degree of managerial concern and that safety is valued, the employees will tend to be positive in their attitudes towards safety, they are more likely to make suggestions and remarks on improving working conditions and will be less inclined to commit unsafe acts.

*Personal Commitment and responsibility:* Employees feel less responsible for safety than managers and defined personal responsibility as a "perceived responsibility for involvement in safety" [51, p 23] where employees are accountable for their own safety and managers for employees' risky behavior. The construct of personal commitment and responsibility was also investigated in some studies [4; 52].

*Job satisfaction* is a common and essential construct of assessment of safety climate and means how satisfied someone feels with their current job [9; 20]. The current study together with job satisfaction and motivation of employees, investigates additionally the relationships with colleagues and employers to clarify the situation within the organization, because job satisfaction in itself does not provide the guarantee of good relationships. Thus, this aspect can interfere with the process of knowledge exchange and collective learning within the organization.

*Co-workers' peer support for safety:* A construct of employee caring for each other (or "Peer support for Safety" is an appropriate and relevant construct to moment-to moment

safety behavior when assessing safety culture [4]. Geller [53] suggests that 'actively caring' occurs when co-workers alert each other when somebody may be exhibiting at-risk behavior or encouraging an employee to perform work safely.

*Involvement in health and safety activities and decision-making:* Safety culture presumes effective communication and employees' safety participation and involvement in health and safety activities. The survey includes questions about the processes and mechanism of information flow as well as about the amount of relevant information available for the employees. Additionally, the current study evaluates and assesses employees' opinion about the incentives encouraging participation in health and safety activities.

The authors emphasize here that the potency of the reciprocal model for analyzing safety culture may be different in any given situation and might be influenced by potentially important internal and external organizational factors like environment, context, governance, relevant regulations, design etc. The reciprocal interactions among psychological, behavioral and organizational variables, which have been recognized and reflected in the major safety culture models, as well as added forth knowledge variable indicate that the four dimensions to measure the overall safety culture of an organization are psychological, behavioral, organizational and knowledgeable aspects of safety culture.

Therefore, in order to validate the assessment of safety climate as an effective means of measuring the overall safety culture, three hypotheses are postulated here:

H1: Safety climate has an impact on the *psychological* aspect of safety culture and contributes to managing safety knowledge.

H2: Safety climate has an impact on the *behavioural* aspects of safety culture and contributes to managing safety knowledge.

H3: Safety climate has an impact on the *organizational* aspects of safety culture and contributes to managing safety knowledge.

## II. METHODOLOGY

*Safety survey*

Survey research using a questionnaire is an effective method to acquire data on attitudes toward issues and relationships between variables. The statistical survey results were complemented by data acquired from a national Work Environment questionnaire survey conducted by Statistics Estonia in 2009, which is a representative survey utilizing employer-employee-linked data, designed specifically to study working environment and to measure safety attitudes, perceptions, values, conflicts and relationships, information dissemination, communication with respect to safety, safety knowledge transfer, job interest and satisfaction, perceived responsibility for and involvements in safety issues, commitment, risk awareness, working conditions and safety measures. The respondents were requested to provide their perceptions of these statements. The questionnaire also included additional items not relevant to the present research and this article. Five ordered response levels were used in the

survey. Respondents were required to rank the factors on a 5-point Likert-type scale between 1 = strongly disagree and 5= strongly agree to each of the statements found in the questionnaire.

*Data Sample Characteristics*

The majority of empirical studies limit their sample to one organization from a specific sector which can cause some doubt about their external validity [54].

The questionnaire was administered anonymously to employees from SMEs from different branches of industry. The current survey comprises a sample of 1757 employees who filled the questionnaires and participated in the study.

The sample consisted of men (52%) and women (48%). Approximately a half (54.2%) of the sample were below 49 years of age and 45.8% were 50 years of age and more (Table 1).

TABLE I
DISTRIBUTION OF SAMPLE DATA BY AGE AND WORK EXPERIENCE

| WORK EXPERIENCE, YEARS | No OF EMPLOYEES | SHARE, % |
|---|---|---|
| Less than 1 year | 27 | 1.5 |
| 1 to 5 years | 842 | 47.9 |
| 6 to10 years | 365 | 20.8 |
| 11 to 15 years | N 1 | 13.7 |
| 16 to 20 years | 125 | 7.1 |
| More than 20 years | 157 | 8.9 |
| **TOTAL** | **1757** | **100** |
| EMPLOYEES' AGE, YEARS | No OF EMPLOYEES | SHARE, % |
| Less than 25 | 90 | 5.1 |
| Between 25 and 49 | 863 | 49.1 |
| More than 50 | 804 | 45.8 |
| **TOTAL** | **1757** | **100** |

Work experience is an important characteristic of this sample. A noteworthy 48% have worked in the same company for 1-5 years.

## III. RESULTS AND DISCUSSION

*Employees' safety culture survey*

The data were analyzed using the Statistical Package for Social Science (SPSS 17.0) software. Statistical t-test of the mean was conducted to check the likely response of the entire population to the issues raised in the questionnaire, based on the sample's ratings. The significance level of hypothesis testing was set as 0.05, which means that there is only 5% probability that the relationship was due to a chance occurrence. The critical rating was set up as '3' because by the definitions of the rating scale, rating above '3' represented 'agree' or 'strongly agree' with the statements of the questionnaire. The number of factors that comprise safety culture has variously between defined as 3 to 19 [51]. The

current survey and test results show that all sixteen (16) statements are statistically significant (Table 2) for the employees' questionnaires. This indicates that all the factors are important in determining the effects of safety climate on safety culture, in particular on managing safety knowledge in the organization. The main data analysis method adopted for this study was Factor Analysis. Factor analysis was used to reduce the 35 safety climate attributes to smaller sets of underlying factors (dimensions). Factor analysis was applied to the thirty five factors stating the effects of positive climate in order to identify the possible underlying patterns among the original variables. This method is used to uncover the latent structure (dimensions) of a set of variables by measuring the correlation of the different factors (sixteen statements) and thus weed out the ones that are not related to each other. Factor analysis allows determining the number and nature of common factors that result in correlations among the factors and to obtain the understanding of the nature and dynamics of their relationships. The combination of the factors into a principal component helps to evaluate and explain the importance of combined factors. Principal components are extracted by the varimax rotation of the original variable and each consecutive component is uncorrelated to the other. The Kaiser method was used in order to pick factors with eigenvalues greater than 1.0.

This method reduces the huge amount of data and separates them into a single uncorrelated component. Factor loadings above 0.6 are usually considered as 'high' and those below 0.4 are as 'low'. After the application of the factor analysis, sixteen (16) factors were grouped into principal components under each main category. Scree plots and eigenvalues greater than one were used to determine the number of factors in each data set. The scree plot for the eigenvalues of 16 variables (factors) is in descending order (see Fig. 3).
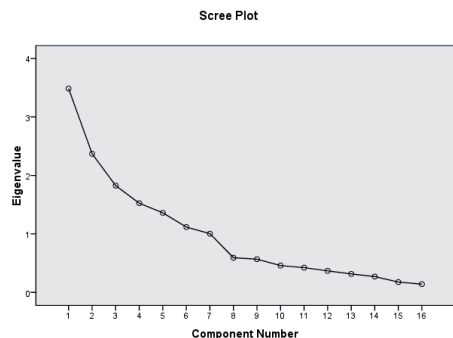


Fig. 3. Scree plot of principal component analysis

Seven principal components were extracted out and the related factors are shown in Tables 3, 4 and 5, which were later on combined into three (3): 'organizational/ environmental/ situational', 'personal/ psychological' and ''job/ behavioral' aspects of safety culture.

The last real factor is considered to be the point before which the first scree begins [55]. Factors with eigenvalues lower than one were not significantly indicated in the first scree plot. The seven (7) key safety climate dimensions identified accounted for approximately 79% of the total variance. The scree plot suggests a possible seven component solution to the principal component analysis.

Table 3 shows that the communalities are high (0.625 to 0.911), the number of expected factors is relatively small (7), and the model error is low due to the high communalities. Therefore, the population factor structure can be adequately recovered.

TABLE III
COMMUNALITIES

| Item | Initial | Extraction |
|------|---------|-----------|
| SC_1 | 1.000 | 0.787 |
| SC_2 | 1.000 | 0.655 |
| SC_3 | 1.000 | 0.732 |
| SC_4 | 1.000 | 0.703 |
| SC_5 | 1.000 | 0.794 |
| SC_6 | 1.000 | 0.789 |
| SC_7 | 1.000 | 0.742 |
| SC_8 | 1.000 | 0.738 |
| SC_9 | 1.000 | 0.808 |
| SC_10 | 1.000 | 0.906 |
| SC_11 | 1.000 | 0.905 |
| SC_12 | 1.000 | 0.625 |
| SC_13 | 1.000 | 0.911 |
| SC_14 | 1.000 | 0.904 |
| SC_15 | 1.000 | 0.856 |
| SC_16 | 1.000 | 0.836 |

*Extraction Method: Principal Component Analysis*

TABLE II
ONE-SAMPLE *T*-TEST OF SIXTEEN SAFETY CLIMATE STATEMENTS

| Item | Statements | Test Value = 3 | | |
|------|-----------|----------------|---|---|
| | | Mean Difference | *t* | Sig. |
| SC_1 | Positive safety climate contributes to my job satisfaction | 1.222 | 64.382 | 0.000 |
| SC_2 | Positive safety climate allows and inspires me to develop skills and knowledge | 1.030 | 39.287 | 0.000 |
| SC_3 | Positive safety climate makes it possible to learn and to create new knowledge at work | 0.694 | 24.089 | 0.000 |
| SC_4 | Positive safety climate contributes to my creativeness and innovation | 0.680 | 23.055 | 0.000 |
| SC_5 | Positive safety climate has positive impact on employees' job content and task satisfaction | 1.171 | 69.291 | 0.000 |
| SC_6 | Positive safety climate increases employees' assuredness and security | 1.561 | 94.875 | 0.000 |
| SC_7 | Positive safety climate improves employment relationships and decreases workplace conflicts | 1.742 | 143.463 | 0.000 |
| SC_8 | Positive safety climate improves relationship between employees and employers and contributes to co-workers peer support for safety | 1.325 | 83.793 | 0.000 |
| SC_9 | Positive safety climate inspires me to work safely and enhances personal responsibility | 1.512 | 106.722 | 0.000 |
| SC_10 | Positive safety climate promotes the management commitment to safety, enhances the effectiveness of allocation of resources | 0.870 | 14.652 | 0.000 |
| SC_11 | Positive safety climate enhances safety knowledge dissemination (i.e. safety training) and supports establishing safety committees and Trade Unions | 1.154 | 19.544 | 0.000 |
| SC_12 | Positive safety climate promotes employees' involvement in health and safety activities and improves safety communication | 1.000 | 43.856 | 0.000 |
| SC_13 | Positive safety climate contributes to establishing Communities of Practice and improving status of safety personnel | 1.009 | 13.651 | 0.000 |
| SC_14 | Under positive safety climate, safety procedures and standards tend to be followed by employees | 1.000 | 23.968 | 0.000 |
| SC_15 | Positive safety climate enhances information and safety knowledge exchange | 0.767 | 35.639 | 0.000 |
| SC_16 | Positive safety climate enhances safety as value admission and possibilities to participate in the decision-making process | 0.643 | 28.536 | 0.000 |

TABLE IV
TOTAL VARIANCE EXPLAINED

| | Initial Eigenvalues | | | Rotation Sums of Squared Loadings | | |
|------|-------|-------------|-------------|-------|-------------|-------------|
| Item | Total | % of Variance | Cumulative % | Total | % of Variance | Cumul. % |
| SC_1 | 3.486 | 21.788 | 21.788 | 2.196 | 13.726 | 13.726 |
| SC_2 | 2.370 | 14.814 | 36.601 | 1.878 | 11.736 | 25.462 |
| SC_3 | 1.826 | 11.411 | 48.012 | 1.876 | 11.728 | 37.189 |
| SC_4 | 1.525 | 9.534 | 57.546 | 1.827 | 11.422 | 48.611 |
| SC_5 | 1.360 | 8.502 | 66.048 | 1.778 | 11.108 | 59.719 |
| SC_6 | 1.117 | 6.982 | 73.030 | 1.597 | 9.982 | 69.701 |
| SC_7 | 1.004 | 6.277 | 79.307 | 1.537 | 9.607 | 79.307 |
| SC_8 | 0.592 | 3.701 | 83.009 | | | |
| SC_9 | 0.568 | 3.550 | 86.558 | | | |
| SC_10 | 0.458 | 2.863 | 89.421 | | | |
| SC_11 | 0.423 | 2.642 | 92.064 | | | |
| SC_12 | 0.368 | 2.300 | 94.362 | | | |
| SC_13 | 0.316 | 1.973 | 96.335 | | | |
| SC_14 | 0.270 | 1.689 | 98.023 | | | |
| SC_15 | 0.176 | 1.102 | 99.125 | | | |
| SC_16 | 0.140 | 0.875 | 100.000 | | | |

*Extraction Method: Principal Component Analysis.*

| | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| SC_1 | .111 | .018 | .198 | .004 | .056 | .846 | 124 |
| SC_2 | .794 | -.047 | .040 | -.024 | .051 | .128 | -.027 |
| SC_3 | .824 | -.002 | .097 | .045 | -.061 | .193 | -.012 |
| SC_4 | .831 | .091 | -.002 | -.028 | -.006 | .009 | .051 |
| SC_5 | .197 | -.027 | .097 | .077 | .055 | .857 | .051 |
| SC_6 | -.061 | .110 | -.022 | -.018 | .878 | .013 | .045 |
| SC_7 | -.039 | .078 | .047 | .107 | .803 | .120 | .249 |
| SC_8 | .070 | .040 | .248 | .119 | .151 | .162 | .778 |
| SC_9 | -.051 | .033 | -.019 | .032 | .070 | .029 | .893 |
| SC_10 | .027 | .942 | -.028 | .107 | .053 | -.004 | .049 |
| SC_11 | .009 | .942 | .010 | .114 | .064 | -.005 | .022 |
| SC_12 | .350 | -.197 | .369 | .152 | .539 | -.020 | -.120 |
| SC_13 | -.021 | .160 | .130 | .928 | -.011 | .014 | .087 |
| SC_14 | .013 | .072 | .090 | .928 | .143 | .070 | .057 |
| SC_15 | .027 | .025 | .902 | .095 | .036 | .154 | .083 |
| SC_16 | .084 | -.028 | .881 | .111 | .058 | .149 | .117 |

Extraction Method: Principal Component Analysis.
Rotation method: Varimax.
Rotation converged in 7 iterations.

*Safety Climate and Organizational Aspects of Safety Culture*

Safety Culture was determined in line with Cooper's [8] and Geller's model [53] whereas a key dimension – a structural or system dimension, in addition to a behavioral dimension, a psychological dimension and knowledgeable dimension were proposed. Each of these dimensions then had a person (psychological aspects), organization (organizational aspects) and job (behavioral aspects) element.

The first principal component related to the organizational (in Geller's model situation/ environment construct) aspects of safety culture (Table 6) is extracted out. The current principle of safety culture refers to the factors related to those factors, which exist in an organization, such as SMs, organization structure, production system and working environment [6; 8; 9; 48; 56]. The statistical t-test results (see Table 2) show that all related factors (SC_10, SC_11, SC_13, SC_14) are statistically significant and it means that they have positive effect on safety climate. According to the results, hypothesis 1 was not rejected and safety climate was established to have a positive impact on the organizational aspect of safety culture with a special focus on management safety knowledge. Results from the current study demonstrated that positive safety climate promotes the management concern and commitment to safety, such as providing necessary resources for safety training and equipment. Under the positive safety climate, managers allocate human and financial resources to the SMs and become personally involved in it [5], which improves communication and safety personnel status in the organization. This is in line with the research findings [9; 57] that positive safety climate promotes not only commitment of

management to accident prevention activities (safety training, tools and equipment) but also to risk management, organization support and safety-related communication, and effective knowledge creation and dissemination [58]. This study, in line with Teo & Feng [9], suggests that positive safety climate improves SMs through better safety communication and knowledge dissemination through the safety committee and CoP. Knowledge is competence to act, and as such it is primarily tacit and can be developed based on participation in a CoP, which allows cooperative learning as learning –in-organizing and based on the sharing of tacit and explicit knowledge and skills among employees [59; 60]. Based on previous research [62], other researchers claimed that "if safety and organizational climate strategically focused on the transfer of safety training, then the relationship between safety knowledge (acquired via training) and safety performance will be facilitated due to organizational members' knowledge and performance being aligned with the goals and commitment of their organization" [61, p 140].

| Item | Factors | Factor loading |
|---|---|---|
| SC_10 | Positive safety climate promotes the management commitment to safety, enhances the effectiveness of allocation of resources | 0.942 |
| SC_11 | Positive safety climate enhances safety knowledge dissemination (i.e. safety training), supports establishing safety committees and Trade Unions | 0.942 |
| SC_13 | Positive safety climate contributes to establishing Communities of Practice and improving status of safety personnel | 0.928 |
| SC_14 | Under positive safety climate, safety procedures and standards tend to be followed by employees | 0.928 |

The current survey suggests that positive safety climate is a key feature of a supportive work environment in which employees are involved in health and safety activities, they feel more comfortable in raising concerns about safety issues, sharing their knowledge and thus are able to learn through imitation and participation [63]. According to researchers [5; 9], under a positive climate, workers are more likely and ready to follow safety procedures, standards, safety policy and rules, less inclined to commit unsafe acts, even when a job is 'rushed' and more likely to make suggestions and comments for improving work conditions.

*Safety Climate and Behavioral Aspects of Safety Culture*

The second principal component is extracted out and related to the behavioral (job) aspects of safety culture (see Table 7). Behavioral aspects of safety culture refer to recognizing occupational hazards, complying, communicating, demonstrating and caring about occupational health and safety issues [53]. The current research focused on several components, for example, what employees know about issues related to safety, how they are satisfied with existing SMs and how employees are motivated to work safely and to provide peer support for safety.

The results from the statistical t-test (see Table 2) show that all the related factors (SC_8, SC_9, SC_12, SC_15, SC_16)

are important and statistically significant; it means they have a positive effect on safety climate. The related factors of this principal component illustrate the relationship between safety climate and behavioral aspects of safety culture. According to the results, hypothesis 2 was not rejected and safety climate was established to have a positive impact on the behavioral aspects of safety culture. The current research demonstrated that the positive safety climate and effective SMs enhance the flow and exchange of knowledge between people and thus create organizational competence regarding to safety. Collective knowledge is fundamental and 'for information and knowledge to flow, the people in the organization must be linked' [64, p14] and connected in the appropriate organizational structure. In order to achieve effective and rapid flow of safety information and knowledge and become learning as well as competent organization, the organization's processes, its people, and its technology need to come together as a management system.

A positive safety climate inspires and motivates employees' work safely and enhances personal responsibility. This is in line with research results [9; 51] that under positive employees' perceptions to safety their willingness and likelihood to comply with safety rules and procedures, standards and regulations is influenced. In addition, several researchers pointed to the linkages between safety climate, safety motivation, and safety knowledge and behavior [9; 65-67]. Furthermore, positive safety climate contributes to co-workers' peer support for safety and improves relationship and communication between employees and employers, and decreases conflicts with work (Table 7). One explanation could be that positive safety climate improves safety information and knowledge dissemination and thus enhances employees' willingness to understand and accept safety management system. These results confirmed the main findings from research in [4; 9]. Other researchers [5] claimed, "firm managers play a fundamental role in reducing the number of unsafe acts by employees, and hence in reducing accident rates" (p. 637). Bosak with colleagues [65] demonstrates that when employees perceive that an organization considers safety to be an essential issue and is valued, also such aspects as safety policies, procedures and management systems are relevant, effective and given priority over competing demands, they are less inclined to engage in risk behavior [8; 68]. Managerial concern and behavior influences compliance with workplace norms as well as which kind of behavior likely to be supported, valued or rewarded in the organization [26]. This relationship between safety climate and the behavioral aspects of safety culture was also confirmed in this study, as the survey results demonstrate that positive safety climate inspires employees to work safely, enhances personal responsibility and contributes to co-workers' peer support to safety. In addition, it enhances safety as a value reward and is admitted/in use in the organization. A positive safety culture prevails in the organization when it has adopted adequate SMs. It requires providing employees with continuous safety training and availability of the relevant safety information for the employers and employees in the

right place at the right time. In addition, this means that an organization has established incentives for the employees to become involved in safety activities; has clearly defined a safety policy that reflects the organization's values and principles regarding safety [5, 69]. It is essential that organizational structure allows and enables the exchange of safety knowledge which means an effective control and feedback system. Another central theme identified in relation to behavioral factors contributing to positive safety culture was worker involvement in health and safety activities.

TABLE VII
BEHAVIORAL ASPECTS OF SAFETY CULTURE

| Item | Factors | Factor loading |
|---|---|---|
| SC_8 | Positive safety climate improves relationship between employees and employers and contributes to co-workers peer support for safety | 0.778 |
| SC_9 | Positive safety climate inspires me to work safely and enhances personal responsibility | 0.893 |
| SC_12 | Positive safety climate promotes employees' involvement in health and safety activities and improves safety communication | 0.539 |
| SC_15 | Positive safety climate enhances information and safety knowledge exchange | 0.902 |
| SC_16 | Positive safety climate enhances safety as value admission and possibilities to participate in the decision-making process | 0.881 |

Positive safety climate promotes employees' involvement and encouraging employees to participate in the decision-making process regarding safety issues. This study, in line with [5; 9], suggests that employees' involvement is fundamental for the proper SMs and it leads to an improvement in relationships in an organization, employees' satisfaction and motivation. If employees feel that they are an important part of the organization and they perceive the high degree of managerial concern and that safety is valued [50] in the organization, the employees tend to be positive in their attitudes towards safety, they will more likely to make suggestions and remarks on improving working conditions and will be less inclined to commit unsafe acts [5]. The effective development of a SMs and prevention of work accidents requires that safety be placed as a principal organizational value as well as full management and supervisors' commitment and employees' involvement [50]. All these factors are a part of SMs and demonstrate managers' commitment.

*Safety Climate and Psychological Aspects of Safety Culture*
The third principal component is extracted out and related to the psychological ('Person' construct) aspects of safety culture, which includes seven safety climate statements (see Table 8). According to the results, all seven safety climate statements are statistically significant based on the t-test results (see Table 2). Thus, hypothesis 3 was not rejected and safety climate was established to have a positive impact on the internal psychological aspects of safety culture, such as knowledge, skills, abilities, relationship, motives and personality of employees.

9

Results from the current study demonstrated that a positive safety climate was perceived to contribute to develop creativeness and innovation of employees, as well as assuredness and security regarding the labour relationship. These results in line with [64; 70], suggest that "an effective management system enables organizational innovation, and this is achieved through the exchange and flow of knowledge between people [64, p15], since "creators learn from experience" [70, p31]. Activities such as working, learning and innovating are closely bound up with each other in a local practice, particularly in the CoP [61].

| Item | Factors | Factor loading |
|---|---|---|
| SC_2 | Positive safety climate allows and inspires me to develop skills and knowledge | 0.794 |
| SC_3 | Positive safety climate makes it possible to learn and to create new knowledge at work | 0.824 |
| SC_4 | Positive safety climate contributes to my creativeness and innovation | 0.831 |
| SC_6 | Positive safety climate increases employees' assuredness and security | 0.878 |
| SC_7 | Positive safety climate improves employment relationships and decreases workplace conflicts | 0.803 |
| SC_1 | Positive safety climate contributes to my job satisfaction | 0.846 |
| SC_5 | Positive safety climate has positive impact on employees' job content and task satisfaction | 0.857 |

Studies on organizational cultures have developed the similar concept of the CoP [71-73]: "where learning happens" [74], "Organizational learning and CoP: Toward a unified view of working, learning, and innovation" [72, 75], "The practice of learning" and "collective learning" [76].

Under the positive safety climate, the improved employment relationship between employees and their employers and co-workers leads to a reduction in workplace conflicts and an improvement in employees' satisfaction and motivation. These findings are consistent with studies [5; 40; 77]. Learning can be through conflict management, since conflict provides the opportunity to listen carefully to the arguments, feelings and needs of others. Based on [78], "well-managed conflict helps individuals confront reality and accept limitations, yet still feel they can influence their situation, conditions, critical for psychological health" (p 33). The conflict can inhibit the dissemination of good safety practice and exchange of the experiential knowledge in the organization [77]. Conflict had an important effect on the behavior of organization members and had to be managed [40]. Conflict can be a positive force that stimulates interest and creativity, identifies and assists in resolving problems and promotes group cohesion [37]. It can also be a stimulus for organizational learning [38]. At the same time, communication, participation in decision-making, sharing valuable knowledge and sharing attitudes and view-points [46], employees' involvement in processes, as well as social good relationships and conflict management are essential factors that promote trust. In order to achieve the collective and shared goals and visions as well as attitudes and understanding between all the employees, an effective knowledge management system is required [35].

A positive safety climate contributes to employees' job content and task satisfaction. This is in line with the findings in [9] that positive safety climate contributes not only to the morale of employees and their work satisfaction, which was shown to be related directly to safety performance.

The close relationship between safety climate and psychological aspect of safety culture has been demonstrated by many other studies [8; 20; 21; 79].

*Gaps Addressed in the Current Model*

There is no survey previously reviewed that incorporate conflict management as a learning instrument and its possible effect on safety culture and knowledge exchange. Thus, this study fills the gap in the literature by including this factor. The current study also investigates relationships between employers and employees as well as co-workers, co-workers' peer support for safety and personal responsibility, which is sparsely reviewed in the literature [4; 5; 24; 51; 53].

*Limitations*

The findings suggest that the safety culture survey is a useful tool for future research; however, this study has several limitations. First, the study was conducted at a specific moment in time, and therefore it is a cross-sectional survey. In this sense, establishing sequential relationship between predictors and outcomes is admittedly difficult. Therefore, a useful avenue for future research would be to replicate the findings in this study with longitudinal data. A second limitation is that a majority of our measures were self-reported, thus introducing the possibility of common method bias.

Despite these limitations, this study revealed findings that have both theoretical and practical significance. Of particular importance are the implications that these findings have for both safety culture and organizational science research. The results suggest that the safety climate factors, particularly the support, commitment, communication provided by management to employees, make an important contribution to safety culture.

*Future directions*

Future research should pay more attention to understanding how organizational values are used in an organization and which factors are affecting their implementation in the organization. There is a need to conduct a survey where the data set of both employees and employers are linked in SMEs. In addition, it would be useful to conduct a comparative safety culture survey based on quantitative and qualitative approaches.

IV. CONCLUSIONS

The present study has examined the subjective architecture of safety culture in the Estonian manufacturing sector in terms of the relationship between organizational, psychological and behavioural aspects of safety culture. A conceptually

innovative Reciprocal Model of Safety Culture with Knowledgeable Dimension was proposed, which can allow in-depth study of the impact of Knowledge Management on the development of safety culture processes as well as to describe the relationship between safety climate and the overall safety culture through the notion of Community of Practice.

The authors present an empirical examination based on a questionnaire survey with a sample of 1757 employees of the relationship between safety climate and the overall safety culture with a new dimension – knowledge management. The results illustrate the importance of positive safety climate in different aspects of safety culture with a special focus on managing safety knowledge within the organization. Factor analysis was conducted to reduce the identified critical safety climate factors into sixteen for the employees. It was concluded that the integrated approaches of safety climate assessment in the current study could provide reliable prediction of the level of overall safety culture and real state of safety in manufacturing SMEs. This approach has the potential to improve the understanding of different features in SMs system in order to managed safety, knowledge and conflicts.

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**Marina Järvis (the corresponding author),** MSc (Bergen University, Norway), at present she is a PhD student at the faculty of Economics and Business Administration, Tallinn University of Technology. Currently she is a lecturer at the Department of Work Environment and Safety, Tallinn University of Technology; 30 scientific papers; she has many times represented Estonia at the international OH&S conferences and participated in relevant projects. Research interests focus on safety culture, knowledge management in OH&S; safety management system; occupational wellbeing. E-mail. Marina.Jarvis@ttu.ee

**Anu Virovere,** MSc (Tallinn University), at present she is a PhD student at the faculty of Economics and Business Administration, Tallinn University of Technology. Currently she is a lecturer at the Faculty of Business Administration, Tallinn University of Technology, Estonian Entrepreneurship University of Applied Sciences, Estonian Business School; 22 scientific papers; she participated in the international conferences. Research interests focus on conflict management, value based management, ethics. E-mail. Anu.Virovere@eek.ee

**Piia Tint,** PhD (Techn. Sciences, 1977) from Leningrad technological Institute of Lensoveta. Professor; the Head of the Department of Work Environment and Safety, Tallinn University of Technology; more than 150 scientific papers, 10 books. Main interest: risk assessment tools, chemical risks, occupational hazards . E-mail: Piia.Tint@ttu.ee

**Appendix 7.**

**Research paper VII**

Järvis, M., Virovere, A., Tint, P. (2013). Managers' perceptions of organizational safety: implication for the development of safety culture. *Scientific Journal of Riga Technical University* (forthcoming, ETIS 1.2).

# Managers' perceptions of organizational safety: implication for the development of safety culture

Marina Järvis1, Anu Virovere 2, Piia Tint 3, 1-3 *Tallinn University of Technology*

*Abstract* –A key feature of a company's safety culture is shared perceptions amongst managers and employees concerning the importance of safety. The purpose of the study was to assess senior managers' perceptions of the current safety culture in Estonian SMEs from different branches of industry, on a sample of 463 senior managers. The relationships of different aspects of safety culture and safety management systems, senior managers and employees perceptions and attitudes to safety were explored through the deployment of different research measures and methods. In addition, a qualitative approach to assessing safety culture is presented. Studies of eight SMEs included observation, analysis of documentation and semi-structured interviews with senior managers and focus group interviews with employees. This paper reports on an empirical examination of the relationship between safety climate and safety culture through a knowledge management dimension with a special focus on management of safety knowledge. The results of this study indicate that safety climate has impact on the three dimensions of safety culture, namely psychological, behavioral and organizational aspects of safety culture. Several specific features of safety and knowledge management, such as management commitment to safety, safety information dissemination, communication and workers' involvement in safety were found to influence the relationship between safety climate and safety culture. It is concluded that the development of 'communities of practice' is an effective way for employees to exchange explicit and tacit safety knowledge.

Keywords – Safety culture, Safety Climate, Knowledge Management, Safety Knowledge, Organizational Values.

## I. INTRODUCTION

Studies have revealed that following occupational safety initiatives leads to an average increase of 71% in cost-benefits, 66% in productivity and 44% in quality [1]. It is estimated that 4 per cent of annual global GDP, or USD 1.25 trillion, is lost due to the direct and indirect costs of occupational accidents and diseases (such as lost working time, interruption of production, medical expenses, and workers' compensation) [2]. Organizations in the United States lose up to 170 billion dollars annually due to occupational injuries (as cited in [3]). The UK Health and Safety Executive estimates the costs to individual occupational accidents and work-related ill health to be between GBP 10.1 and GBP 14.7 billion (or EUR 11.5 to 16.7 billion); the costs to employers to be between GBP 3.9 and GBP 7.8 billion (approximately EUR 4.4 to EUR 8.9 billion) and the costs to society of workplace accidents and work-related ill health to be between GBP 20 to GBP 31.8 billion (approximately EUR 22.7 to EUR 36.1 billion) [4; 5]. At the same time, good safety management systems (SMs) can positively affect not only accident rates and

safety performance of organization, but also have a positive influence on competitiveness performance, economic-financial performance of an organization and on the control of workers' safe behavior [5; 6]. According to [2], many companies, especially small and medium-sized enterprises (SMEs), have viewed occupational health and safety (OH&S) as a necessary element of compliance rather than as a contributory factor to the economic viability of their organization. At the same time, estimates suggest that these enterprises have serious problems aggravated by limited access to human, economic, technological resources as well as lack of relevant safety knowledge in order to deal with OH&S [7].

A safe and healthy working environment is an important element of work life quality [8]. Safety through technical design is still entirely relevant to ensuring safe and healthy work systems, but in itself it is now regarded as insufficient. As a part of safety management system (SMS), it is important to focus on managerial and organizational factors. Attention in recent years has shifted towards attempting to better understand the psychological and social preconditions for employee's unsafe behavior and accident causation. Over the past two decades, many researchers [6; 9-12] and practitioners have shown increasing interest in the concept of safety culture because of its impact on safety outcomes of the organization such as injuries, fatalities, and other incidents.

When safety becomes a value and is demonstrated through employers' and employees' individual attitudes, perception, and behavior, the process develops into a safety culture. The concept of 'safety culture' has been developed and is seen as a sub-unit of organizational culture, alluding in particular to individual characteristics, the nature of the work tasks and the organizational features that may affect and influence organization's on-going health and safety performance [10]. Schein [13] claims that the way in which senior managers reward, instruct, allocate resources and their attention as well as behavior under the pressure, will be particularly salient in shaping organizational (safety) culture. Other researchers [14; 15] suggested that perceptions of senior managers' attitudes and behaviors in relation to the health and safety, well-being of workforce will form the basis for the safety behavior of employees, and therefore, the safety performance of the organization.

Previous collaborative research by this writer has shown empirically that many managers have started showing an interest in safety performance and their conclusion is that intervention should be directed towards employees and

employees' behavior [16]. However, the newest investigations show that the changing of safety climate and culture in organizations (in particular, in SMEs) is also really a matter of changing managers' behavior. The behavior-based safety approach may be effective for reactive safety management by modifying behavior and improving compliance behavior. Such behavior is also one of the main issues (together with situations and person factors) identified in the model of safety culture as the key factor which is applicable to the accident causation chain at all levels of an organization [10; 17]. Positive safety culture requires stronger institutional pressure, where all the employees and the employer commit and participate in health and safety activities as well as relevant organizational structure in order to share values and practical safety knowledge and to exchange (tacit and explicit) knowledge [6; 18, 19].

The most common construct in the safety culture survey is the perception of leadership and management/supervisors' attitudes and behaviors around safety [20; 21]. According to [3; 18], management should encourage safe behavior of employees. Like previous research [7], this suggests leadership (management and supervisors) should spend more time on the floor with employees and build trust, which is vital for the opportunity to convert tacit knowledge into explicit shared knowledge. Management commitment also can be demonstrated by allocation of the resources in the field of OH&S.

There is a variety of quantitative and qualitative data collection tools available that can be used to measure the psychological, behavioral and situational/organizational aspects of safety culture [3; 10; 11; 18; 22]. Cooper emphasis the necessity to use more than one methodological angle (so-called triangulation) in order to evaluate overall safety culture in the organization [10]. Recent reviews of safety culture measures have revealed many potential factors that could make up an overall safety culture [11; 20]. However, there is still little consensus available regarding what are the reliable core factors of safety culture are and whether the measure of safety climate can be a reliable indicator of overall safety culture. Frazier with colleagues have addressed the necessary core safety culture factors, for example, peer support for safety, safety management systems, personal responsibility for safety, and management support for safety [3].

The current study was conducted in Estonia for various reasons. First, the recent annual reports of the National Labour Inspectorate (2008-2011) present evidence that working environment and the employer awareness concerning OH&S in Estonian manufacturing SMEs needs improvement. Second, although significant progress has been made in accident prevention in Estonia during the most recent years, empirical evidence of the combined fatal and serious incident rates, especially among young and new workers, suggests that this is still an area where greater public policy intervention might be warranted. Third, the results from the analysis of the cost of implementing the

main topics of Occupational Health and Safety regulations for Estonian enterprises [23] revealed that employers considered OH&S as a cost-burden, especially costly for the SMEs. This study concludes that Estonian employers waste much time and money due to the lack of relevant information and knowledge in the field of OH&S and there is a need for radical change [23]. In sum, the public policy goal of promoting a high level of SMS and safety culture, particularly in the predominant SMEs sector has received very little attention in Estonia.

This article examines relationships between safety climate and safety culture, tests an innovative conceptual Safety culture model proposed in previous research [24], based on employers' responses. Focus is on organizational safety culture and the structure or architecture of employees' and employers' attitudes to safety as part of that culture, as well as the ability to learn, which also should mean changes in workers' behavior in order to enhance safety culture.

The authors emphasize that the potency of the reciprocal model [24; 25] for analyzing safety culture may be different in any given situation and might be influenced by potentially important internal and external organizational factors like environment, context, governance, relevant regulations, design etc. The reciprocal interactions among psychological, behavioral and organizational variables, which have been recognized and reflected in the major safety culture models, as well as the added fourth knowledge variable indicate that the four dimensions to measure the overall safety culture of an organization are psychological, behavioral, organizational and knowledgeable aspects of safety culture. Therefore, in order to validate the assessment of safety climate as an effective means of measuring the overall safety culture, three hypotheses are postulated here:

H1: Safety climate has an impact on the *psychological* aspect of safety culture and contributes to managing safety knowledge.

H2: Safety climate has an impact on the *behavioural* aspects of safety culture and contributes to managing safety knowledge.

H3: Safety climate has an impact on the *organizational* aspects of safety culture and contributes to managing safety knowledge.

## II. METHODOLOGY

*Research Design and Instrumentation*

Since OH&S is a multidisciplinary and complex field, some researchers [14; 10] have argued that safety culture cannot be completely understood through traditional quantitative methods, which attempt to break down a phenomenon in order to study its individual components. Safety culture therefore requires the use of both qualitative methods [26] and quantitative methods. Cooper [10] argues that determination of safety culture through a safety climate measure (questionnaire) has a tendency to focus purely on the way people feel and how they perceive safety in an

organization rather than the real and essential aspects of safety culture, like the actual behavior of employees, the real safety situation and safety environment in an organization. The current authors in their previous research [7; 16; 27] have investigated the differences between 'formal' safety and 'real' safety in Estonian SMEs in different industries, indicating some important safety flaws and drawing attention to contextual variables in the development and management of safety cultures.

This research employed quantitative methods in order to explore psychological, behavioral and organizational/ environmental aspects of safety culture (employers' and employees' attitudes, perceptions toward OH&S, values, conflicts and relationships, information dissemination, risk awareness and employees' involvement). In addition, qualitative methods were used in order to focus on a limited number of case studies and individuals, producing in-depth information, to investigate real safety situation in SMEs, with the intention to bring understanding to the concept of safety culture and real safety behavior in the investigated companies (Fig. 1).
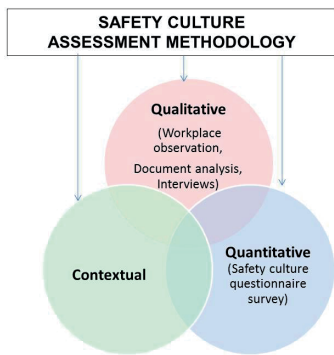


Fig. 1. Methodology of safety culture assessment

According to Cooper [10], alternative or supportive measures for capturing and analyzing the psychological aspects of safety culture include focus group interviews and discussion groups and document analysis. The behavioral aspects of safety culture can be evaluated via observations, and from such sources like risk assessment, accidents and near-misses analysis and reporting documentation, standard operating procedures, the number of weekly inspections completed, the number of audits conducted. The situation aspects of safety culture can be examined from organizational policies, operating procedures, management systems, audits and communication flows [28] as well as from risk assessment reflecting working environment (occupational hazards) and via safety audits of SMS. Thus, a qualitative study approach allows studying the complexity of factors – as they are related to workers, their behavior and interactions with the SMS of the organization.

*Safety interviews. Case studies.*

Measurement of safety culture in terms of the attitudes and perceptions of respondents (employees) about the priorities of safety in their organization is essential, but a survey (questionnaire) alone cannot measure the actual behaviors in the workplace and the real safety situation in the organization. Thus, the qualitative studies were conducted by the authors in order to understand the underlying dynamic processes that need to be supported in pursuit of a 'good' safety culture and to determine an organization's true motives for developing SMS, norms and rules for dealing with occupational risk.

Following the model of Cooper [10] into measurements, the supportive research methods were also adopted. The case studies were intended to promote better understanding of the rationale of current safety culture in Estonian manufacturing SMEs. Results from qualitative studies [7; 16; 25; 27] were used in order to complement and verify the results gained from the safety survey. The exploratory study was based on workplace visits, observations, audits and semi-structured interviews with senior managers, as well as focus group interviews with workers. Observations of safety culture performance indicators in the workplace were performed based on the checklist. The visual assessment includes, for example, hazard registers; workplace layout and cleanliness; personal protective equipment usage and storage; working conditions; condition of plant/ equipment; safety information displayed in general and at workstations etc. The selected enterprises were SMEs (less than 250 workers), from different branches of industry (the metal industry (3), the textile industry (2), manufacture of devices and the plastic processing industry (2), and the printing industry (1), and from various geographical locations in Estonia. Eight semi-structured face-to-face interviews with senior managers in charge of production operations, quality sections of their companies were conducted. The study focused specifically on the perceptions of senior managers, exploring their attitudes and management concern regarding safety, how they care for employees and their enforcing of safety policies and regulations within their respective business and industry; knowledge in OH&S, their commitment to safety, responsibility, cooperation with OH&S specialists (occupational health physicians) [27]. The interviews were conducted in Estonian and Russian languages. Each interview with managers lasted two hours on average and was recorded. Interviews were then fully transcribed and analyzed. Data for this exploratory study were gathered from 8 focus group interviews with 22 industrial workers (13 males and 9 females) [27]. A simple random sample was selected from workers employed at the SMEs. The objective was to gather information about workers' attitudes and perceptions to safety, shared visions and values, safety practices, safety communication and feedback, participating in safety committees, peer support for safety among co-workers, safety knowledge, and their involvement in safety management activities. Each focus group session lasted 45 minutes on average and was

recorded. Interviews were then fully transcribed and analyzed. Every effort was made to protect the privacy, confidentiality, and anonymity of individuals and organizations participating in this study. The interviews were analyzed in the previous study [7; 27]. In addition, the SMS were evaluated in each investigated SMEs through the audit and document analysis for key safety culture indicators. Relevant supplementary safety documents, such as safety strategy and policy, plan and instructions, risk assessment, safety rules and procedures, safety audits and inspections, safety meetings/ committees, safety records, including incidents and accident investigations, training and meeting records, were also carefully analyzed in order to compliment and verify the data collected during the interviews. In detailed working environment and conditions in the investigated SMEs the data were analyzed and presented in previous research [7; 16; 27]

*Safety survey*

The statistical survey results were complemented by the data acquired from a national Work Environment questionnaire survey conducted by Statistics Estonia in 2009, which is a representative survey utilizing employer-employee-linked data, designed specifically for studying working environment and measuring safety attitudes, perceptions, values, conflicts and relationships, information dissemination, communication with respect to safety, safety knowledge transfer, job interest and satisfaction, perceived responsibility for and involvements in safety issues, commitment, risk awareness, working conditions, and safety measures. The respondents were requested to provide their perceptions of these statements. The questionnaire also included additional items not relevant to the present research and article. Five ordered response levels were used in the survey. Respondents were required to rank the factors on a 5-point Likert-type scale between 1 = strongly disagree and 5= strongly agree to each of the statements found in the questionnaire. The substantive parts of the paper present recent comparative survey evidence from the quantitative and qualitative safety survey.

*Data Sample Characteristics*

The majority of empirical studies limit their sample to one organization from a specific sector which can cause some doubt about their external validity [29]. Thus, to achieve as high degree of generalization as possible for the results of the current work, the authors considered the target population made up of manufacturing SMEs from different branches of industry (see Table 1).

There were two similar questionnaires for employers and employees to measure the effects of safety climate upon the overall safety culture and management of safety knowledge. Two questionnaires were administered anonymously to employees and employers from SMEs from different branches of industry. The current survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. The employees' questionnaire was analyzed in our previous study [24].

TABLE I
DISTRIBUTION OF SAMPLE BY ACTIVITY, SIZE

| ACTIVITY SECTORS, Industry | POPULATION | RESPONSE RATE, % |
|---|---|---|
| Agriculture, forestry, fishing | 39 | 80.1 |
| Mining industry | 47 | 70.9 |
| Processing industry, textile-, chemical-, paper-, plastics-, wood-, metal industry | 49 | 58.9 |
| Electricity-, gas supplier | 40 | 71 |
| Water supply; sewerage; waste- and pollution treatment | 43 | 66.8 |
| Construction | 51 | 55.8 |
| Wholesale business, retail business. Machinery, vehicle repair | 56 | 57.1 |
| Transport, warehousing | 32 | 56.6 |
| Other manufacturers | 27 | 55.8 |
| Health care, social assistance | 79 | 64.5 |
| **TOTAL COMPANIES** | **463** | **63.8** |
| SIZE (no. employees) | No OF COMPANIES | RESPONSE RATE, % |
| 5-9 | 150 | 27.6 |
| 10-49 | 197 | 34.9 |
| 50-249 | 110 | 19.5 |
| More than 250 | 6 | 18 |
| **TOTAL COMPANIES** | **463** | 100 |

A special feature of the survey is that it is the first linked data set of both employees and employers in SMEs exploring inter alia issues of employees' involvement, representation, responsibility for workplace safety and health, management and employees' commitment to safety; support; importance and relevance of the safety requirements and procedures, training, information and safety knowledge; how resources are allocated; how safety is valued and appreciated throughout the investigated organizations. The higher response rate was from the organizations with less than 50 employees (Table 1). We found companies with less than 250 employees to be more reluctant to respond to the questionnaire, which leads to a lower response rate from that type of companies.

## III. RESULTS AND DISCUSSION

*Senior managers' safety culture survey*

The data were analyzed using the Statistical Package for Social Science (SPSS 17.0) software. Statistical t-test of the mean was conducted to check the entire population's likely response to the issues raised in the questionnaire, based on the sample's ratings. The significance level of hypothesis

4

testing was set as 0.05, which means that there is only 5% probability that the relationship was due to a chance occurrence. The critical rating was set up as '3' because by the definitions of the rating scale, rating above '3' represented 'agree' or 'strongly agree' with the statements of the questionnaire. The number of factors that comprise safety culture varied from 3 to 19 [30].

The current survey and test results show that all ten (10) statements are statistically significant (Table 2) for the employers. This indicates that all the factors are important in determining the effects of safety climate on safety culture. Factor analysis was applied to the thirty (30) factors stating the effects of positive climate in order to identify the possible underlying patterns among the original variables.

TABLE II
ONE-SAMPLE $t$-TEST OF SIXTEEN SAFETY CLIMATE STATEMENTS

| Item | Statements | Test Value = 3 | | |
|---|---|---|---|---|
| | | Mean Difference | $t$ | Sig. |
| 1_Sc | Positive safety climate enhances information and safety knowledge exchange | 1.268 | 36.450 | 0.000 |
| 2_Sc | Positive safety climate promotes employees' involvement in health and safety activities and improves safety communication | 1.076 | 31.070 | 0.000 |
| 3_Sc | Positive safety climate enhances safety knowledge dissemination and establishing of Communities of Practice | .951 | 38.453 | 0.000 |
| 4_Sc | Positive safety climate promotes the management commitment to safety, enhances the effectiveness of allocation of resources | .998 | 41.235 | 0.000 |
| 5_Sc | Positive safety climate has positive impact on management commitment to safety and law compliance (labor and safety legislation) and thus increases trust | .674 | 11.919 | 0.000 |
| 6_Sc | Positive safety climate improves relationships between employer and employees and decreases workplace conflicts | .706 | 12.089 | 0.000 |
| 7_Sc | Positive safety climate promotes managers' support, their willingness to provide feedback | .585 | 9.843 | 0.000 |
| 8_Sc | Under the positive safety climate, safety procedures, rules and standards tend to be followed and fulfilled | .734 | 18.976 | 0.000 |
| 9_Sc | Positive safety climate enhances the effectiveness of risk management and improves the status of safety personnel | .678 | 15.861 | 0.000 |
| 10_Sc | Under the positive safety climate, safety is valued by senior managers and created the possibilities for employees to participate in the decision-making process | .659 | 15.156 | 0.000 |

This method is used to uncover the latent structure (dimensions) of a set of variables by measuring correlation of the different factors and thus weeds out the ones that are not related to each other. Factor analysis allows determining the number and nature of common factors that result in correlations among the factors and to obtain the understanding of the nature and dynamics of their relationships. The combination of the factors into a principal component helps to evaluate and explain the importance of combined factors. Principal components are extracted by varimax rotation of the original variable and each consecutive component is uncorrelated to the other. The Kaiser method was used to pick factors with eigenvalues greater than 1.0. This method reduces the huge amount of data and separates them into single uncorrelated component. Factor loadings above 0.6 are usually considered as 'high' and those below 0.4 are as 'low'. After the application of the factor analysis, ten (10) factors were grouped into principal components under each main category.

In this study we identified four (4) main categories using Scree plot. Scree plots and eigenvalues greater than one were used to determine the number of factors in each data set. The scree plot for the eigenvalues of 10 variables (factors) in descending order (see Fig. 2).
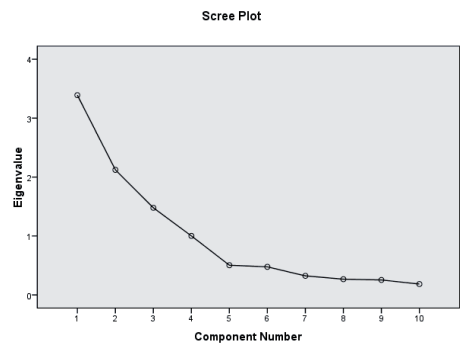


Fig. 2. Scree plot of the principal component analysis

The last real factor is considered to be the point before which the first scree begins [31]. Factors with eigenvalues lower than one were not significantly indicated in the first scree plot. Four (4) principal components were extracted out and the related factors are shown in Tables 3, 4 and 5, which were later on combined into three (3): 'organizational', 'psychological' and ''behavioral' aspects of safety culture.

Table 3 shows that the communalities are high (.673 to .875), the number of expected factors is relatively small (4), and the model error is low due to the high communalities. Therefore, the population factor structure can be adequately recovered.

TABLE III
COMMUNALITIES

| Item | Initial | Extraction |
|---|---|---|
| 1_Sc | 1.000 | .762 |
| 2_Sc | 1.000 | .818 |
| 3_Sc | 1.000 | .832 |
| 4_Sc | 1.000 | .836 |
| 5_Sc | 1.000 | .836 |
| 6_Sc | 1.000 | .875 |
| 7_Sc | 1.000 | .843 |
| 8_Sc | 1.000 | .821 |
| 9_Sc | 1.000 | .696 |
| 10_Sc | 1.000 | .673 |

*Extraction Method: Principal Component Analysis.*

TABLE IV
TOTAL VARIANCE EXPLAINED

| Item | Initial Eigenvalues | | | Rotation Sums of Squared Loadings | | |
|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumul. % |
| 1_Sc | 3.390 | 33.902 | 33.902 | 2.555 | 25.545 | 25.545 |
| 2_Sc | 2.123 | 21.230 | 55.132 | 2.277 | 22.775 | 48.320 |
| 3_Sc | 1.478 | 14.781 | 69.912 | 1.698 | 16.981 | 65.301 |
| 4_Sc | 1.002 | 10.017 | 79.929 | 1.463 | 14.629 | 79.929 |
| 5_Sc | .503 | 5.035 | 84.964 | | | |
| 6_Sc | .476 | 4.760 | 89.724 | | | |
| 7_Sc | .323 | 3.232 | 92.956 | | | |
| 8_Sc | .267 | 2.669 | 95.625 | | | |
| 9_Sc | .254 | 2.537 | 98.162 | | | |
| 10_Sc | .184 | 1.838 | 100.000 | | | |

*Extraction Method: Principal Component Analysis.*

TABLE V
ROTATED COMPONENT MATRIX

| | Component | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| **1_Sc** | .045 | .844 | .214 | .055 |
| **2_Sc** | .129 | .875 | .071 | .178 |
| **3_Sc** | .107 | .087 | .901 | .028 |
| **4_Sc** | .053 | .128 | .902 | .062 |
| **5_Sc** | .903 | .072 | .119 | .031 |
| **6_Sc** | .927 | .121 | .023 | .030 |
| **7_Sc** | .912 | .092 | .057 | -.009 |
| **8_Sc** | .023 | .082 | .045 | .901 |
| **9_Sc** | .010 | .366 | .051 | .748 |
| **10_Sc** | .122 | .780 | .000 | .225 |

*Extraction Method: Principal Component Analysis.*
*Rotation method: Varimax with Kaiser Normalization.*
*Rotation converged in 5 iterations.*

### Safety Climate and Organizational Aspects of Safety Culture

The first principal component is extracted out and the related factors are shown in Tables 6. This principal component is related to the organizational/ situational aspects of safety culture based on the perception survey of senior managers. The statistical t-test results from senior managers' responses (see Table 2) also show that related factors (3_Sc, 4_Sc, 8_Sc and 9_Sc) are statistically significant and it means they have a positive effect on safety climate based on senior managers' responses. Thus, hypothesis 1 was not rejected and safety climate was established to affect the organizational aspects of safety culture.

TABLE VI
ORGANIZATIONAL ASPECTS OF SAFETY CULTURE

| Item | Factors | Factor loading |
|---|---|---|
| 3_Sc | Positive safety climate enhances  safety knowledge dissemination and establishing of Communities of Practice | 0.901 |
| 4_Sc | Positive safety climate promotes the management commitment to safety, enhances the effectiveness of allocation of resources | 0.902 |
| 8_Sc | Under the positive safety climate, safety procedures, rules and standards tend to be followed and  fulfilled | 0.901 |
| 9_Sc | Positive safety climate enhances the effectiveness of risk management and improves the status of safety personnel | 0.748 |

A positive safety climate promotes the commitment of management to safety, which has been recognized as a basic element of safety culture. Management support of safety also led employees to accept responsibility and ownership for safety. These results are consistent with Zohar [32] studies. A review of the literature reveals the importance of managers support to safety and leadership for safety culture and effective SMS.

According to the results from employees' and employers' perception survey, there are common organizational factors which have a positive impact on the organizational aspects of safety culture, for instance: promotion of management concern and commitment to safety, providing necessary resources as well as intention to follow safety procedures by employees.

### Safety Climate and Behavioral Aspects of Safety Culture

The related factors of the second principal component are shown in Table 7. These three factors shed light on the relationship between safety climate and the behavioral aspects of safety culture.  The statistical t-test results from senior managers' responses (see Table 2) also show that three related factors (1_Sc, 2_Sc, 10_Sc) are statistically significant and it means they have a positive effect on safety climate based on senior managers' responses. Thus, hypothesis 2 was not rejected and safety climate was established to affect the behavioral aspects of safety culture.

TABLE VII

BEHAVIORAL ASPECTS OF SAFETY CULTURE

| Item | Factors | Factor loading |
|---|---|---|
| 1_Sc | Positive safety climate enhances information and safety knowledge exchange | 0.844 |
| 2_Sc | Positive safety climate promotes employees' involvement in health and safety activities and improves safety communication | 0.875 |
| 10_Sc | Under the positive safety climate, safety is valued by senior managers and the possibilities for employees are created to participate in the decision- making process | 0.780 |

The current study, in line with some researches [6; 33], suggests that managers have a direct influence through their positive attitudes towards safety and through their positive attitudes, active commitment and behavior.

According to the results from employees' [24] and employers' perception survey, there are common factors which have a positive impact on the behavioral aspects of safety culture, but employees emphasized that the positive safety climate enhances not only employees' personal responsibility, but also contributes to co-workers' peer support to safety.

*Safety Climate and Psychological Aspects of Safety Culture*
The third principal component is extracted out and the three related factors are shown in Table 8.

This principal component is related to the psychological aspects of safety culture based on the perception survey of senior managers. Table 8 indicates that three factors (5_Sc, 6_Sc, 7Sc) are all significantly important. Thus, hypothesis 3 was not rejected and safety climate was established to influence the psychological aspects of safety culture.

TABLE VIII

PSYCHOLOGICAL ASPECTS OF SAFETY CULTURE

| Item | Factors | Factor loading |
|---|---|---|
| 5_Sc | Positive safety climate has a positive impact on management commitment to safety and law compliance (labor and safety legislation) and thus increases trust | 0.903 |
| 6_Sc | Positive safety climate improves relationships between employer and employees and decreases workplace conflicts | 0.927 |
| 7_Sc | Positive safety climate promotes managers' support, their willingness to provide feedback and to allocate resources in order to activate safety management system | 0.912 |

Managers have influence through their support, funding for establishing and development of the SMS. These findings are consistent with [6].

To compare the results from employees' and employers' perception survey, it is essential to underline that a positive safety climate contributes to the employees' job satisfaction, creativeness and innovation.

*The organizational context of safety culture*
As described in the proposed model, based on the above analysis, safety climate has a significant impact on all three aspects of overall safety culture, like organizational, behavioral and psychological aspects. However, perception surveys are not enough in order to assess and evaluate existing overall safety culture and real safety behavior in the organization.

The statistical analysis of safety culture questionnaires shows many organizations with an outstanding safety culture and positive safety attitudes. However, qualitative data indicate some important safety weaknesses and aspects which should be included in the process of evaluation of safety culture in an organization [7]. The results from the case studies, workplace observation, document analysis and interviews with senior managers as well as focus group interviews with employees, collectively contributed to a comprehensive description and assessment of the safety culture in manufacturing SMEs. Detailed results from qualitative survey studies, working environment and conditions in the investigated SMEs were analyzed and presented in previous research [7; 16; 25; 27; 25; 34].

There is a need for a holistic exploration of safety culture, which is influenced by both structure and processes in the organization [35]. There are three major interrelated elements/forces which are simultaneously influencing the behaviour of the employees within organizations. These forces are the structure (which outlines the formal organization, i.e. the proposed allocation of power and responsibilities, mechanism of communication, coordination and control), culture (outlines assumption, individual and group values, attitudes, beliefs, risk-perceptions, competencies, norms, principles, and patterns of behavior) and processes (rules, procedures, supervision). Together they provide the context of behavior, i.e. safety behavior, in the organization.

Qualitative approaches to safety culture assessment in the current study provided by workplace observation, document analysis and safety interviews indicated some important safety flaws [7; 27]. The main aspects of safety culture are analyzed and presented below:
• *Safety is a clearly recognized value in the organization.* Most of the investigated SMEs showed rather a positive attitude towards contributing to safety: developing safety practices and written work procedures, risk assessment, investigating occupational accidents, providing safety training and occupational health services for the employees. However, the main shortfalls of the SMS were in gaps between formal and real safety that was discovered [7]. Qualitative results obtained show that in all investigated enterprises, safety is generalized as a formal or propagated value [7; 36], safety was not valued throughout all investigated SMEs due to lack of everyone's commitment to safety. Still, the attitudes of the employees and employers were generally positive, many differences were found between work groups, and between management and staff.

Employees were not willing to talk about safety issues and they did not actively participate in health and safety activities. Therefore strong safety communication problems exist in many enterprises [27; 34]. In addition, decision-making in the organizations was strictly top-down process in all investigated SMEs and, generally, employees are neither actively involved in health and safety activities nor in the decision-making process. Employees in many SMEs generally are not inhibited in raising any safety concerns.

It is essential that employees' health and safety behavior as organizational values are adopted and shared between all employees throughout the organization and not only formally existing. Reviews of organizational values surveys have identified some common constructs related to such values [36] as: described, propagated (formal) and shared or real values. Employees' attitudes and safety behavior are based on adopted and recognized values. Therefore it is essential that these values can be introduced through management principles, good practices in occupational health and safety, as well as through employers' and employees' commitment to safety on a daily basis [7].

• *Senior managers' concern and commitment to safety, how it is evident at all levels in the organization. The necessary allocation of resources, including time, equipment, personnel and finance, is being made.*

According to results from the qualitative survey, there is a lack of resources (human and financial) allocated to the field of OH&S in Estonian SMEs. Employees perceive that resources for employees (training, occupational health service, health promotion programmes) are a low priority. One possible reason for that could be the economic situation at the time of the study when all organizations tried to reduce costs, including those related to the occupational health and safety. Virovere with colleagues [37] stated that the investigated management values have changed in 2009 (versus 2007), but the need for knowledge management and learning as a value in the organization is not pointed out.

According to the results from the interviews with senior managers, there is a lack of management awareness and commitment to safety. There are still a few incentives and little motivation, especially from relevant Estonian legislation for employers to deal with OH&S issues in Estonia [7; 27]. The effectiveness of the present OH&S system in Estonia is undermined by the insufficient coverage of occupational health services, lack of political will to meet EU occupational health and safety requirements, lack of relevant statistical data and research activities, too weak penalties and the continuing absence of an insurance act for occupational accidents and diseases [25; 27; 34].

Personnel perceive that management is placing a high emphasis on issues related to production and quality of the product and less attention has been paid to environment, safety and health issues. It means that there is a need to improve visibility and involvement of management in safety-related activities. An integrated and cohesive

organizational safety leadership process does not yet exist in Estonian SMEs.

• *Roles and responsibilities are clearly defined and understood.*

Senior managers and employees have the clearest perception of their roles and responsibilities. Employees and employers share common perceptions of responsibility for managing workplace risks. Most of the employees and all employers are more likely to assume that the employer has responsibility for controlling workplace risks. At the same time, employers pointed out that they expect more responsibility for safety from their employees (that responsibility for safety should be shared). During the focus group interviews, employees stated that they do not usually discuss health and safety issues with colleagues and do not show actively co-workers' support to safety.

The current study is in a line with [18; 30] shows that the positive safety climate enhances not only employees' personal responsibility to safety but also contributes to co-worker peer support for safety.

• *Safety is integrated into all activities in the organization.*

Results from the study reveal that safety is not yet consistently integrated into all activities in the investigated eight SMEs. Processes and programs are in various stages of transition, relevant information and existing safety knowledge is generally distributed between different departments which often reduce their effectiveness. In addition, the quality of documentation and processes needs to be controlled and improved in six of the eight SMEs. However, in all of the investigated Estonian enterprises written safety procedures for work operations and safety instructions were established. Most employers considered working environment in their enterprise as safe [16; 27] and in all investigated enterprises written safety guidelines and procedures exist, but their fulfilment was not periodically updated and monitored.

The issues of the conflict, as a part of the culture, were sensitive in all the investigated SMEs. Therefore, it was not recognized, and certainly not openly and honestly acknowledged. The subject related to the possible conflicts between employers and employees or co-worker was regarded as negative and irrelevant and, thus, rejected. This attitude is typical for the organization that does not recognize the positive power of conflict in the innovative and learning process. Essential aspects of the positive safety culture are the managers' commitment, the employees' involvement and the effective SMS [6]. The established SMS have to be a fully integrated part of its general management system in the organization that addresses occupational accident prevention; preparedness and response (see Fig. 3). The SMS should include the organizational structure, practices, procedures and resources for implementing the safety policy. In order to codify personal tacit knowledge into explicit and practical knowledge for all employees within the organization, it is essential that the process of the safety knowledge

management needs to be acknowledged and valued by the management.

Establishing of the Community of Practice (CoP) can be moderated by organizational climate (supportive and open reporting culture that is blame-free) and organizational structure (less formalized, less centralized and more integrated) as well as managed.
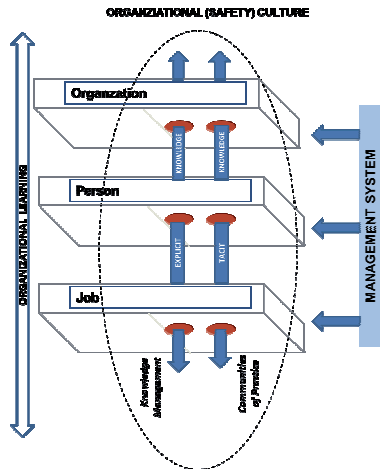


Fig. 3. Tacit and Explicit knowledge management

• *Safety Culture is learning driven in the organization.*

According to the results from safety survey, safety was not learning-driven in the investigated SMEs. Efforts to improve future performance by learning from past performance and experience, and from the day-to-day implementation of the organization's programs and processes, are not systematic or recognized to be of high value for the organization.

Efforts have been undertaken recently to provide greater management support and attention to the corrective action plan system in all investigated SMEs, especially for training, not always in the field of occupational health and safety. Our study results revealed that information, both internal and external, is distributed and communicated throughout the organizations by various mechanisms, e.g., e-mails, pre-job briefs, guidelines, written safety instruction, Intranet, and work orders. Although employees demonstrated good awareness of the risks and safety measures in their work environment, some problems still exist in the transmission, comprehension and implementation of the safety information and knowledge, as well as insufficient and formal safety training provided for employees, especially for the new employees [7]. During workplace visits and the interviews, gaps concerning how safety knowledge is transferred were analyzed. Some safety knowledge transfer barriers found in all investigated enterprises were emphasized, such as lack of time and

willingness to share information, language issues and expertise [7; 27; 34].

Overall, employees were conscious of the importance of working safely; they do not feel that avoiding responsibility out of fear of being punished is a behavior that is valued within the organization. Nevertheless some scepticism still remains with respect to having a truly blame-free environment. According to the results from focus group discussions with employees, there is also a need to establish an open reporting culture that is blame-free.

*Gaps Addressed in the Current Model*

There is no survey previously reviewed incorporating conflict management as a learning instrument and its possible effect on safety culture and knowledge exchange. Thus, this study expands on a key gap in the literature by including this factor. The current study also investigates relationships between employers and employees as well as co-workers, co-workers peer support for safety and personal responsibility, which is sparsely reviewed in the literature [3, 6, 20, 30, 38].

*Limitations*

The setting for this study, in particular, made it difficult to identify safety activities and behaviors that would apply to all employees and employers throughout the investigated organizations in the manufacturing sector. In addition, eight case studies (observations, audits) and a limited number of interviews may represent a small sample. Thus, further research with a larger number of people, including safety managers, must be conducted. The results from the current quantitative and qualitative research cannot be generalized to other small and medium-sized enterprises and play an illustrative role without further research.

Despite these limitations, this study revealed findings that have both theoretical and practical significance. Of particular importance are the implications that these findings have for both safety culture and organizational science research [24]. From a more practical standpoint, it is likely that senior managers can benefit from a balanced approach to safety that includes traditional safety management activities (i.e. management of physical or tangible resources/ assets, such as safer technology, regular audits, hazards identification, proper risk assessment; use of less hazardous chemicals and the elaboration of safe procedures, safety policies and guidelines etc), but special attention should be given to intangible resources/ assets which comprise what we have called here, the CoP (i.e. employees' capabilities, competence, skills, organizational and safety culture, the company's image, an organization's resources and way of action and the relationships).

*Future directions*

Future research should pay more attention to understanding how organizational values are used in an organization and which factors affect their implementation in the organization. More research should be conducted in

order to test the proposed model of safety culture and to further validate the survey. Another kind of study approach would be more suitable for probing deeper into safety culture issues at the organizational level, focussing on safety performance and the actual behavior, safety promotion, safety policy and procedures, safety awareness, creation and transfer safety knowledge. In addition, it would be useful to study how an organization can support collective learning in the field of occupational health and safety as well as on identifying the relevant organizational indicators of safety culture, measuring safety culture and organizational values, how these are interrelated and change over time especially in small and medium-sized enterprises. In addition, it would be valuable to obtain information on the safety managers, occupational health specialists, to evaluate the effect of some safe working condition.

## IV. CONCLUSTIONS

The present study has examined the subjective architecture of safety culture in the Estonian manufacturing sector in terms of the relationship between organizational, psychological and behavioral aspects of safety culture. A conceptually innovative Reciprocal Model of Safety Culture with Knowledgeable Dimension was tested with a sample of 463 employers, which can allow in-depth study of the impact of Knowledge Management on the development of safety culture processes as well as to describe the relationship between safety climate and the overall safety culture through the notion of Community of Practice.

An overview of the safety culture in SMEs was evaluated through multiple data collection. The authors present an empirical examination based on a questionnaire survey with a sample of 463 employers and 1757 employees [24] of the relationship between safety climate and the overall safety culture with a new dimension – knowledge management. Supportive measures for capturing and analyzing the psychological, behavioral and organizational aspects of safety culture included observations, semi-structured in - depth interviews with senior managers, focus group discussions with employees, document analysis and audits. Eight case studies were undertaken to study how in each case the SMS is integrated into the strategic management system, working environment, formal and real safety, the design of a safety knowledge management system and model of safety culture with knowledge management dimensions, safety information needs as well as information sources.

The results illustrate the importance of positive safety climate in different aspects of safety culture with a special focus on managing safety knowledge within the organization. Factor analysis was conducted to reduce the identified critical safety climate factors into sixteen for the employees [24] and ten for the employers. It was concluded that the integrated approaches of safety climate assessment in the current study could provide reliable prediction of the level of overall safety culture and real state of safety in manufacturing SMEs. This approach has the potential to improve the understanding of different features in SMS system in order to manage safety, knowledge and conflicts.

From a theoretical perspective, this study is one of the first to evaluate safety climate dimensions with a special focus on knowledge management systems as an umbrella for capturing a range of organizational concerns in order to enhance learning and performance in an organization. This study concerns organizational safety culture and the structure or architecture of employees' and employers' attitudes to safety as part of that culture, as well as the ability to learn, which also should mean changes in workers' behaviour through establishing communities of practice and conflict management in order to enhance safety culture.

Based on the previous research and the results of the study it can be concluded that the need for the knowledge-based change in the field of occupational health and safety in Estonia is urgent, which could be also one of the effective and most powerful strategies for organizational development. There is also a need for effective knowledge management training –for a support system in order to provide an organization with strategic advantages and help to develop learning environment which can help create and maintain skills in safety and therefore create the positive safety culture. Based on the surveys, authors emphasize that two main factors in the process of managing of safety knowledge and organizational learning essential for strengthening and enhancement of SMs are: development of communities of practice (gives a possibility for learning and transmitting practical safety knowledge and, thus, for collective learning) and supportive and harmonized safety culture where knowledge-sharing is valued by everyone in the organization.

The authors believe that the presented Reciprocal Model of Safety Culture with Knowledge Management System Dimensions can assist in the on-going analyses and implementation of a positive safety culture.

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**Marina Järvis (the corresponding author),** MSc (Bergen University, Norway), at present she is a PhD student at the faculty of Economics and Business Administration, Tallinn University of Technology. Currently she is a lecturer at the Department of Work Environment and Safety, Tallinn University of Technology; 30 scientific papers; she has many times represented Estonia at the international OH&S conferences and participated in relevant projects. Research interests focus on safety culture, knowledge management in OH&S; safety management system; occupational wellbeing. E-mail. Marina.Jarvis@ttu.ee

**Anu Virovere,** MSc (Tallinn University), at present she is a PhD student at the faculty of Economics and Business Administration, Tallinn University of Technology. Currently she is a lecturer at the Faculty of Business Administration, Tallinn University of Technology, Estonian Entrepreneurship University of Applied Sciences, Estonian Business School; 22 scientific papers; she participated in the international conferences. Research interests focus on conflict management, value based management, ethics. E-mail. Anu.virovere@eek.ee

**Piia Tint,** PhD (Techn. Sciences, 1977) from Leningrad technological Institute of Lensoveta. Professor; the Head of the Department of Work Environment and Safety, Tallinn University of Technology; more than 150 scientific papers, 10 books. Main interest: risk assessment tools, chemical risks, occupational hazards . E-mail: Piia.Tint@ttu.ee

# Appendix 8. Occupational Health Physicians' survey questionnaire

## Questionnaire for Occupational Health Physicians

### A. Background information

1. **Sex**     ☐₁ male    ☐₂ female
2. **Are you providing Occupational Health Services (OHS)?**    ☐₁ yes  ☐₂ no
3. **Experience in years in the field of OHS** _____ **years**
4. **What kind of agreement do you have?**

   ☐₁ Providing OHS is my main job        ☐₂ Providing OHS is my second job
5. **Which kind of organisation you are working in ?**

   ☐₁ Occupational Health Services
   ☐₂ OH unit (department) in Hospital
   ☐₃ Private entrepreneur (FIE)
   ☐₄ other, please specify _____
6. **Position held in the organisation?**_____
7. **For how many people are you yourself a foreman?**_____
8. **How long have you been working in this organisation? _____ years**

### B. Training

1. **Years since graduation as professional _____ years**
2. **Have you attended the specialisation courses for occupational physicians?**
   ☐₁ yes      ☐₂ no
3. **Specialisation; specialist training in _____ (also if under way )**
   ☐₁ When acquired ?        _____
   ☐₂ Where acquired ?       _____
   ☐₃ Under way, expected date and place ?_____
4. **Language ability:**
   **1-  do not understand, 2- poor/insufficient, 3- average, 4-good, 5-very good,**
   **6-mother tongue**

|                   | Understanding | Speaking | Writing |
|-------------------|---------------|----------|---------|
| a. Estonian       | -             | -        | -       |
| b. Russian        | -             | -        | -       |
| c. English        | -             | -        | -       |
| d. Other          | -             | -        | -       |
| e. _____ | -             | -        | -       |

5. **How many courses related to OH&S you have attended during the past 3 years?**

| Issue | Organisation | Course duration (hours) | Year |
|-------|--------------|-------------------------|------|
|       |              |                         |      |
|       |              |                         |      |
|       |              |                         |      |
|       |              |                         |      |
|       |              |                         |      |

# Questionnaire for Occupational Health Physicians

6. **On which issues listed below would you need more training? Choose the <u>three</u> most important issues** in order of importance by marking the most important with 1, the second most important with 2, and the third most important with 3.

| Issue | |
|---|---|
| a. OHS and OH&S legislation, regulations and guidelines | |
| b. Risk Assessment and analysis of physical risk factors at work | |
| c. Risk Assessment and analysis of chemical risk factors at work | |
| d. Risk Assessment and analysis of biological risk factors at work | |
| e. Risk Assessment and analysis of psychological risk factors at work | |
| f. Risk Assessment and analysis of ergonomics at work | |
| g. Health examinations | |
| h. Rehabilitation and/or promotion of work ability | |
| i. Ergonomics | |
| j. Prevention and health education | |
| k. Occupational diseases and work related diseases (diagnostics, care and prevention) | |
| l. Personal protection devices | |
| m. First aid readiness | |
| n. Health and safety management | |
| o. General health issues | |

## *C. Tasks in the field of OH&S at work*

**1. Your total average weekly working hours in different tasks in OH&S____hours**

**2. Tasks and duties (average hours/week used):**

| Activity | Number of enterprises | Hours/week |
|---|---|---|
| a. Workplace visits | | |
| b. Health examinations | | |
| c. Rehabilitation/Planning of rehabilitation | | |
| d. Health promotion activities (health education etc.) | - | |
| e. Promotion of general occupational health | | |
| f. Diagnosing occupational- and work-related diseases (documentation) | | |
| g. First-aid readiness/training | - | |
| h. Activities related to maintaining work ability | - | |
| i. Risk assessment | - | |
| j. Employers' advice in choosing personal protective equipment, ergonomics solutions, stress etc. | - | |
| k. Employees' advice in choosing personal protective equipment, ergonomics solutions, stress etc. | - | |
| l. Cooperation and collaboration with other organisations | - | |
| m. Administration, everyday paperwork | - | |
| n. Planning and reporting | - | |
| o. (Marketing) Promoting of services | - | |
| p. Assessment of work related stress | | |
| r. Other tasks/duties, specify: | | |

3. **How often do you participate in risk assessment activities at the workplace?**
$\square_1$ daily $\square_2$ weekly $\square_3$ monthly $\square_4$ couple of times/ year $\square_5$ not at all

4. **How many people besides you are involved into risk assessment activities in your organisation?** _____

5. **Is the risk assessment where you participated followed by the health examination?**
$\square_1$ always $\square_2$ mostly/often $\square_3$ seldom $\square_4$ never

6. **Do you perform the health examination on the basis of existent (the employer has got it) risk assessment?**
$\square_1$ always $\square_2$ mostly/often $\square_3$ seldom $\square_4$ never

7. **Do you visit workplaces before performing the health examination?**
$\square_1$ always $\square_2$ mostly/often $\square_3$ seldom $\square_4$ never

Please specify, based on what you would decided to visit organisation or not:
_____


## D. Performing the monitoring and evaluation

1. **What kind of additional occupational health practice you are performing:**
$\square_1$ assessment of work ability index,
if **no**, then **why** (please specify) _____
$\square_2$ clients welfare and well being questionnaire
$\square_3$ work stress questionnaire
$\square_4$ measurements of occupational hazards
$\square_5$ working environment council meetings' protocols and reports
$\square_6$ other (please specify): _____

2. **Do you have feedback procedure (services, product, quality, customer satisfaction, compaints) from client?**
$\square_1$ jah $\square_2$ ei

**How is the consumer satisfaction with OHS measured and analysed?** (Please, specify)
_____

3. **How is organized good practice in occupational health? (** (Please, specify)
_____

4. **Are you also involved in providing health services?**
a. $\square_1$ yes b. $\square_2$ no
If **yes**, how many average weekly hours?_____

5. **Other work you are involved in (e.g., teaching, research, etc.); please, specify:**

Please, specify: _____

Average weekly hours?_____

6. **What kind of agreement do you have with employer/ organisation in order to perform occupational health services (during the last 2 years, 2007-2008):**
☐1 *Constant agreement/contract* (1 year or longer)
☐2 *One-time* (f.ex. only to carry out the health examination at once)
☐3 Other (Please specify) _____

## D. Equipment, additional services

**1. Which technical equipment you use in your daily practice?**
_____
_____

**2. Would you need some additional equipment?**    ☐1 yes  ☐2 no
If **yes**, please specify:
_____
_____

**3. Which additional services do you use (laboratories, specialists in other disciplines etc.), please specify:**
_____
_____

## E. Information sources

1. **Available professional literature:** Where do you search the information you need in your practice?

☐1 Handbooks, guidelines          ☐2 Legal provisions, directions etc.
☐3 Professional literature          ☐4 Training
☐5 Other  (please specify) _____

2. **Available information sources for problem solving:**

☐1 Colleagues (recommendations and advices from other specialists)
☐2 Universities                    ☐7 Labour Inspectorate
☐3 Occupational health Centre (PERH)   ☐8 Ministry of Social Affairs
☐4 Professional networking in Estonian  ☐9 International professional networking
☐5 International professional books    ☐10 Professional books in Estonian
☐6 International professional magazines  ☐11 Professional magazines in Estonian
☐12 Other  (please specify) _____

3. **Do you know where to find answers to the legal question in your practice?**  ☐1 yes  ☐2 no
If **yes,** then **where** ? (please specify) _____

4. **Do you have the possibility to use computer?**    ☐1 yes  ☐2 no

If yes, do you have access to Internet**?**    ☐1 yes  ☐2 no

If yes, on average how many hours per week you use Internet for information search_____?

**Questionnaire for Occupational Health Physicians**

*F. Practices*

1. **Do you have a possibility to collaborate with other professionals according to your need?** ☐₁ yes ☐₂ no

If, **no** the reasons for this are:

☐₁ no information about the professional

☐₂ lack of the professional (not trained in our country)

☐₃ other (please specify)_____

2. **How often you have to collaborate/cooperate with professionals as follow:**

| | *Often (daily)* | | | | *Seldom (once /year)* |
|---|---|---|---|---|---|
| An employer (enterprise) | 1 | 2 | 3 | 4 | 5 |
| Senior managers, production managers | 1 | 2 | 3 | 4 | 5 |
| Human resource manager/ specialists | 1 | 2 | 3 | 4 | 5 |
| Safety manager | 1 | 2 | 3 | 4 | 5 |
| Working environment representatives | 1 | 2 | 3 | 4 | 5 |
| Working environment council | 1 | 2 | 3 | 4 | 5 |
| Research and training institutions | 1 | 2 | 3 | 4 | 5 |
| Training and expert organisations | 1 | 2 | 3 | 4 | 5 |
| Social security, Social Insurance Board (Ministry of Social Affairs) | 1 | 2 | 3 | 4 | 5 |
| Health promotion organisations (specialists) | 1 | 2 | 3 | 4 | 5 |
| First aid and the Estonian Rescue Board | 1 | 2 | 3 | 4 | 5 |
| Clerks (Labour Inspectorate etc.) | 1 | 2 | 3 | 4 | 5 |
| Occupational Physicians Association | 1 | 2 | 3 | 4 | 5 |
| Occupational Health Centre (SA PERH) | 1 | 2 | 3 | 4 | 5 |
| Other (please specify) _____ | 1 | 2 | 3 | 4 | 5 |
| _____ | 1 | 2 | 3 | 4 | 5 |

3. **Practice in collaboration with professionals and leaders in order to organise better work in the working environment**

   a) What kind of problems you have to deal with?

   _____

   _____

   b) How often are you participating in dealing with these issues?

   ☐₁ daily ☐₂ weekly ☐₃ monthly ☐₄ couple of times/ year ☐₅ not at all

4. **Practice in suspected occupational diseases:**

   a. How many patients with suspected occupational disease you encountered during the past **12 months** in your practice?_____

   b. Where do you refer, if needed, the patient with a suspected occupational disease?___

   _____

## Questionnaire for Occupational Health Physicians

 c. Do you get feedback of these patients, please specify?   _____
  _____

 d. Needs for improvement in diagnosing and treating occupational diseases ?_____
  _____

**5. Are you aware about the possibilities in professional rehabilitation/ retraining and career consulting in Estonia?** ☐₁ yes ☐₂ no

**If yes, do you use them?** ☐₁ yes ☐₂ no

6. **Do you feel, that there is difficult to stay impartial in your work:** ☐₁ jah ☐₂ ei

7. **Do you discuss the issue of occupational health ethics among your colleagues?**
    ☐₁ yes ☐₂ no

8. **Do occupational health physicians receive training in occupational health ethics?**
    ☐₁ yes ☐₂ no

9. **Are you interested in training course "ethics in occupational health physicians' practice"?**  ☐₁ yes ☐₂ no

10. **What kind of ethical guidelines do you use in your practice? (Please specify)**
 _____

11. **Do you have good teamwork at your occupational health department?**
 ☐₁ yes ☐₂ likely yes ☐₃ likely no ☐₄ no ☐₅ I do not know

12. **Do you have the positive climate at your occupational health department (positive communication climate etc)?**
13. ☐₁ yes ☐₂ likely yes ☐₃ likely no ☐₄ no ☐₅ I do not know

14. **Availability of statistics on sickness absence**
 a. Do you get any statistics of sickness absence ☐₁ yes ☐₂ no

 If **yes**:

   a. Total number of days   ☐₁ yes ☐₂ no

   b. Department level statistics  ☐₁ yes ☐₂ no

   c. Sick fund level statistics  ☐₁ yes ☐₂ no

15. **What kind of aspects negatively affects/ influence quality of occupational physicians work in Estonia:**

☐₁ lack of professional guidelines/ information materials in Estonian (please specify)

_____

☐₂ absence of data about workers' health ?

☐₃ difficulties to reach state registers

☐₄ low quality of risk assessment  ☐₅ absence of risk assessment

☐₆ lack of time (shot period of audience with patient for the health examination)

☐₇ lack of time (a lot of administrative work)

# Questionnaire for Occupational Health Physicians

☐₈ lack of knowledge in occupational health

☐₉ lack of employers' motivation to deal with OH&S

☐₁₀ the absence of the Compulsory Insurance Act of Occupational Diseases and Accidents

☐₁₁ Other (please specify) _____

**16. Are the workers afraid of telling about diseases/ health problems they have,**

   ☐₁ yes    ☐₂ no

If **yes**, please specify? _____

**17. Are the workers aware about the consequences of health examination?**

   ☐₁ always    ☐₂ mostly/often    ☐₃ seldom    ☐₄ sometimes ☐₅ never

18. **Are the workers informed about occupational hazards?**

   ☐₁ always    ☐₂ mostly/often    ☐₃ seldom    ☐₄ sometimes ☐₅ never

**19. Please specify, according which aspects you decide the amount of procedures during the health examination?**
   The decisions are based on:

☐₁ occupational hazards in the working environment

☐₂ workers' health

☐₃ technical abilities/ available technical equipment

☐₄ clients' (employers') wishes

☐₆ patients' wishes

☐₇ special /ready packages for health examination

☐₈ the same health examination procedures, which have been performed by previous occupational physician

☐₉ Other (please specify) _____

**20. What kind of worker's sickness profile /health impairments discovered most often during the health examination?**
   _____
   _____

**21. At workplaces people encounter psychosocial problems and conflicts e.g., they feel they are treated unequally and unfairly or they feel mobbing and harassment. Do people tell you about these problems?**    ☐₁ yes    ☐₂ no

   If yes, what kind of problems, and do men and women differ in their reactions?
   _____

**22. What do you think are the main priorities and major problems in the OH&S practice in Estonia?**
   _____

   _____

Questionnaire for Occupational Health Physicians

**23. What kind of problems you have to deal with during the providing occupational health services?**

_____

_____


## G. Relationship with employer, collaboration

1. **According your opinion, the employers are well informed about relevant OH&S legislation?** ☐₁ yes ☐₂ no

2. **According your opinion, the senior managers are motivated to maintain and promote the work ability of workers? (the employers value the issues of OH&S)**
☐₁ yes ☐₂ likely yes ☐₃ likely no ☐₄ no ☐₅ I do not know

3. **According your opinion, the employers are ready for collaboration and cooperation with occupational health physicians in order to maintain and promote the work ability of workers?**
☐₁ yes ☐₂ likely yes ☐₃ likely no ☐₄ no ☐₅ I do not know

4. **Are employers apply occupational physicians' recommendations after health examination in order to improve working environment?**
☐₁ always ☐₂ mostly/often ☐₃ seldom ☐₄ never
☐₅ I do not know, because of the feedback absence

5. **According your opinion, the tasks and responsibilities performed by occupational physicians overlap (are the same) with tasks listed in relevant OH&S legislation?**
☐₁ yes ☐₂ no

If **no**, what kinds of differences are most important? (Please specify)

_____

_____

_____

*H. Cases.* *(The imaginary case presented to the respondents)*

*Please, try to answer what would you do in the situation as follows:*

*Case 1.* The worker himself wants to continue the job in spite of the disease (hand carpal tunnel syndrome). What would you do?

☐$_1$ You give to worker written statement in which you consider him unsuitable for the job.

☐$_2$ You ask for an outside expert's opinion *e.g,. from the Occupational Health Centre (SA PERH)*

☐$_3$ You propose a new examination later

☐$_4$ You give him a written statement on the restrictions at work and consult the employer about the safety procedures at the work place

☐$_5$ Some other solution, what (please specify)

_____

_____

_____

**I. Contact information (voluntary):**

Your Name:_____

Organisation where you are working:    _____

Address:_____

Telephone (work):    _____

Mobile telephone:_____

Fax: _____

E-mail:_____

*Thank You for Your participation!*

**Appendix 9. Interview plan**

# Appendix 9. Interview plan (Manager Interviews)

The participant is expected to describe the decision process/mechanism associated with the OH&S in organization. The overall objective is to explore how companies organize OH&S, formulate safety strategies, and value the issue of health and safety.

- elements of the safety culture as perceived by the participant
- role-ordered aspects/people involvement (initiation, participation, response)
- steps of the decision process (regarding formation and/or realization of safety strategy); sequence or order of the these steps if any
- temporal dimension of the process (if possible)
- possible causal relationships among the elements/steps
- perceived formality associated with process (OH&S strategy communication, strategy documenting, planning-implementation precedence, rewarding)

Given below is a set of sample questions that would be used during the face to face semi-structured interviews with senior managers in order to stimulate discussion.

*Introduction (*Topic and expectations / Confidentiality, open discussion, notes)

*Company information*

- OH&S structure, strategies. Organizational history: critical incident
- The most significant change(s) in the field of OH&S in the past years
- Safety records (accidents, diseases) – possible causes and consequences
- Investments in OH&S. Possible costs related to poor OH&S; to the occupational accidents and/or occupational diseases
- Implementation of OH&S management systems, (also other e.g., quality management systems (QMS), environmental management systems (EMS), and Total Quality Management (TQM)

*Safety culture. Safety Training, information dissemination, informational sources, commitment to safety*

- Opinion about the safety. How safety defined and described (examples, if possible) How safety culture is expressed in the organization.
- Safety and health as values (how these issues are taken into account in the organization. Stories and, examples.
- The concept 'safety culture' – the possible meaning (example, if possible).
- The characteristics of a company with a strong safety culture
- The important elements, which can help to create a good safety culture
- Perception of management attitude towards safety (the key tasks in OH&S)
- Motivation for change(s) (safety culture, politics, strategy). Initiatives have been used in order to support the safety (as a value). In what sense (example)

- Goals or objectives (both short–term and long–term) for health and safety; how does maintaining workforce ability support/contribute to achieving overall business goals
- What are the internal organisational factors that have affected the OH&S strategy process most? (e.g. cultural, structural, political, individual)
- What are the external (market/environmental) factors that have affected the OH&S strategy process most? (e.g. industry factors competition related factors, broader economic factors, regulatory effects, lack of relevant info, legislation etc)
- Attitudes in the company towards safety culture (description, examples)
- Cultural dynamics (safety practice, norms, rules and procedures)
- Factors, which influence the OH&S in the organization and possibilities for improvement (particular safety culture).
- Managers' role in promoting safety culture. Opinion about the statement: "The things to which the managers pay systematic attention will be culture"
- Safety training received. Development and learning (learning from accidents/ near-misses, safety training and course)
- Safety measures, OH&S intervention – analysis, priorities. The competing pressures of production and safety.
- Perceived appropriateness of safety training. How evaluate the effectiveness of the safety training.
- The awareness about the main occupational hazards in the organization
- Safety measures are in place in order to ensure that employee exposure to those hazards is eliminated or controlled (demonstration of the safety leadership)
- Procedures and systems which are in place to ensure organization's risks assessment and evaluation
- The mechanism which is in place to generate and share/disseminate/deploy OH&S information within and across the functional boundaries of the organisation (visit the plant, audits, monitoring/ inspection)
- Description of the investigation the working environment (type of audit procedures , risk assessment)
- The importance of the issues in the field of OH&S to be discussed at the board-level meetings. (demonstration the board's commitment to health and safety)
- Punishment consequences (safety behaviour). Opinion about reaction of the managers when critical events arise.
- Supervisors and safety *(How do you hold your supervisors accountable for safety and health? Have you ever had to discipline a supervisor for not following the rules?)*
- Tools to measure safety culture.
- Responsibilities in the field of OH&S.
- What have you done to ensure your organisation, at all levels including the board, receives competent health and safety advice?
- Cooperation with OH&S professionals (Occupational Health Services; the rationality of the provision of OHS, Labour inspectors)
- Record-keepers (responsibilities, how rekord-keeping organized – centralized/ computerized

*Employee involvement*

- Health and safety activities, in which employees participate
- Possibilities for feedback/ recommendations
- Description of the mechanism how employees are involved in learning and training programmes; development of the competence in OH&S

- Perception of employee attitude towards safety
- Safety representatives, Trade Union
- Safety training, availability to participate in different courses
- General comments on managing employee morale/motivation in OH&S

*Relationship between employer and employees, co-workers*

- Relationship with employees
- Conflicts (stories and examples) and Conflict Management

*Knowledge management (KM). Critical factors for knowledge management*

- Information source used in the field of OH&S in order to solve problems (EU materials, Labour Inspectorate, media, OH&S professionals, conference/ course)
- Knowledge management is considered important in the organization
- Perception and opinion of the role of human factor in KM
- Information technology in place for support KM
- Possible barrier for safety knowledge dissemination and transfer (language, time, willingness to share, teamwork, structure in place)
- Safety training of new employees
- Systems for managing safety knowledge
- Culture and support for managing safety knowledge in the organization
- Possibility to learn (the quality of training is monitored; there a periodic review of training needs)

# Interview plan (Employee, focus group discussion)

Given below is a set of sample questions that would be used during the face to face focus group interviews with employees in order to stimulate discussion.

*Introduction*  (Topic and expectations / Confidentiality, open discussion, notes)

*Employee involvement*

- Description of the mechanism how employees are involved in learning and training programmes;  OH&S activities, in which employees participate
- Possibilities for feedback/ recommendations

- Perception of attitude towards safety
- Describe, how employees are involved in setting OH&S standards and riles, accidents investigation and measuring and auditing activities (story, examples)
- Safety representatives, Trade Union
- Safety training, availability to participate in different courses, motivating
- Participation in risk assessment; encouraging and motivation to report unsafe conditions, near-misses

*Employer commitment*

- Senior management commitment (Does a senior manager participate in health and safety meetings?) Describe how managers/supervisors show interest in safety.
- Regular safety inspections/ monitoring, carried out by mangers
- Perception of management attitude towards safety
- Review of safety performance (Does senior management receive regular reviews of the safety performance?)

*Safety culture. Relationship between employer and employees, co-workers. Awareness about occupational hazards and safety measures*

- Identify the main occupational hazards in the workplace; safety measures
- List of activities associated with occupational risk prevention (opinion/evidence for each risk)
- Information on how the situation in OH&S has changed for recent 5-10 years
- Relationship with employer/ co-workers
- Conflicts (stories and examples) and Conflict Management
- Competence and safety training; informational sources (the opinion of the employees about the competence in OH&S issues that affect their work)
- Co-operation, communication
- Safety culture. (*the same topics as for senior managers*)
- Risk factors, safety measures (Personal Protective Equipment, etc.)
- Possibilities to get current safety information
- Responsibilities, safety practice, safety documentation
- Occupational Health Services, health promotion
- Required safety information (what kind of, in real time; what form – paper form etc.)

# Demographics for Study Participants (interviews)

| Organisation | Branch of industry | Partici-pant | Age | Gender | Position | Type of interview | Language |
|---|---|---|---|---|---|---|---|
| A (Case I) | metal processing | 1 | 42 | F | Quality manager | SS interview | Russian |
| A (Case I) | metal processing | 2 | 47 | M | Welder | FG interview | Russian |
| A (Case I) | metal processing | 3 | 52 | M | Master | FG interview | Estonian |
| A (CaseI) | metal processing | 4 | 29 | M | Project manager | FG interview | Estonian |
| A (Case I) | metal processing | 5 | 47 | F | Safety Manager | SS interview | Estonian |
| B (Case II) | metal processing | 6 | 48 | M | Techno-logy director | SS interview | Estonian |
| B (Case II) | metal processing | 7 | 37 | M | Welder | FG interview | Russian |
| B (Case II) | metal processing | 8 | 49 | M | Welder | FG interview | Russian |
| B (Case II) | metal processing | 9 | 56 | M | Master | FG interview | Russian |
| B (Case II) | metal processing | 10 | 36 | M | Safety Manager | SS interview | Russian |
| C (Case III) | metal processing | 11 | 62 | M | Safety Manager | SS interview | Estonian |
| C (Case III) | metal processing | 12 | 37 | M | Techn. director, CEO | SS interview | Russian |
| C (Case III) | metal processing | 13 | 45 | M | Welder | FG interview | Russian |
| C (Case III) | metal processing | 14 | 56 | M | Master | FG interview | Russian |

| Case | Industry | # | Age | Sex | Position | Interview type | Language |
|------|----------|---|-----|-----|----------|----------------|----------|
| C (Case III) | metal processing | 15 | 39 | M | Master | FG interview | Russian |
| D (Case IV) | Textile / clothing | 16 | 35 | F | Quality manager | SS interview | Estonian |
| D (Case IV) | Textile / clothing | 17 | 51 | F | HR manager/ safety manager | SS interview | Russian |
| D (Case IV) | Textile / clothing | 18 | 36 | F | Dressmaker | FG interview | Russian |
| D (Case IV) | Textile / clothing | 19 | 42 | F | Dressmaker | FG interview | Russian |
| D (Case IV) | Textile / clothing | 20 | 39 | F | Dressmaker | FG interview | Russian |
| E (Case V) | Textile / clothing | 21 | 48 | M | Technology director | SS interview | Estonian |
| E (Case V) | Textile / clothing | 22 | 33 | F | Safety manager | SS interview | Estonian |
| E (Case V) | Textile / clothing | 23 | 40 | F | Dressmaker | FG interview | Russian |
| E (Case V) | Textile / clothing | 24 | 45 | F | Dressmaker | FG interview | Russian |
| F (Case VI) | Plastic processing | 25 | 38 | M | Quality manager | SS interview | Estonian |
| F (Case VI) | Plastic processing | 26 | 36 | M | Safety manager | SS interview | Estonian |
| F (Case VI) | Plastic processing | 27 | 28 | M | Specialist | FG interview | Estonian |
| F (Case VI) | Plastic processing | 28 | 58 | M | Master | FG interview | Estonian |
| F (Case VI) | Plastic processing | 29 | 40 | M | Master | FG interview | Estonian |
| F (Case VI) | Plastic processing | 30 | 31 | M | Fitter | FG interview | Estonian |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| G (Case VII) | Plastic processing | 45 | 62 | F | HR manager/ Safety Manager | SS interview | Estonian |
| G (Case VII) | Plastic processing | 32 | 37 | M | Producti on manager | SS interview | Estonian |
| G (Case VII) | Plastic processing | 33 | 62 | F | Worker | FG interview | Estonian |
| G (Case VII) | Plastic processing | 34 | 45 | M | Specialis t | FG interview | Estonian |
| H (Case VIII) | Printing | 35 | 62 | M | Vice president | SS interview | Estonian |
| H (Case VIII) | Printing | 36 | 53 | F | HR manager/ Safety Manager | SS interview | Estonian |
| H (Case VIII) | Printing | 37 | 45 | F | Factory worker | FG interview | Estonian |
| H (Case VIII) | Printing | 38 | 50 | F | Factory worker | FG interview | Estonian |

*\* SS - Semi-structured interview; FG - Focus group interview*

# Appendix 10. Description of the enterprises selected for case studies

Appendix 10.  Description of the enterprises selected for case studies (Composed by the author)

| Code | Branch of industry | Year established | Number of employees | Basic capital (€) | Turnover (€) | Main health hazards measured | Data collection methods performed |
|------|-------------------|-----------------|---------------------|-------------------|--------------|------------------------------|-----------------------------------|
| A | Metal processing / manufactures various products made of cold-rolled steel, galvanised steel and stainless steel, copper and aluminium by the means of cutting | 1991 | 190 | 25 005 | 13 911 875 | Indoor climate, lighting, noise, welding dust, O3, CO, NO-NO2 | Work site observation, Semi-structured interviews; Focus group interviews; Documents and homepages analysis |
| B | Metal processing / Treatment and coating of metals. Repair of fabricated metal products. | 1947 | 240 | 960 000 | 370 151 000 | Indoor climate, lighting, noise, welding dust, O3, CO, NO-NO2 | Observation, Semi-structured interviews; Focus group interviews; Documents analysis |
| C | Metal processing / Manufacture of structural metal products.  Manufacture of other tanks, reservoirs and containers of metal | 1996 | 136 | 76 680 | 13 399 563 | Indoor climate, lighting, noise, welding dust, O3, CO, NO-NO2 | Observation, Semi-structured interviews; Focus group interviews; Documents analysis |
| D | Textile /clothing industry/ Manufacture of workwear | 1991 | 110 | 32 000 | 3 080 683 | Indoor climate, lighting, noise, textile dust | Observation; Audit; Risk Assessment; Semi-structured interviews; Focus group interviews; Documents analysis |
| E | Textile/ clothing industry /. Wholesale of other clothing and clothing accessories | 1990 | 124 | 31950 | 7 375 248 | Indoor climate, lighting, noise, textile dust *OHSAS 18001:2007 established* | Work site observation; Audit; Risk Assessment; Semi-structured interviews; Focus group interviews; Documents and homepages analysis |
| F | Plastic processing /Manufacture of plastic packing goods, rubber elements and details | 1990 | 160 | 300 000 | 7 361 337 | Indoor climate, lighting, noise, hydrogen fluoride *OHSAS 18001:2007 established* | Observation; Audit; Risk Assessment; Semi-structured interviews; Focus group interviews; Documents  analysis |
| G | Plastic processing /Manufacture of plastic packing goods and medical devices | 1991 | 48 | 30800 | 3 674 628 | Indoor climate, lighting, noise, general dust | Observation; Audit; Risk Assessment; Semi-structured interviews; Focus group interviews; Documents analysis |
| H | Printing / Printing of periodicals, commercial catalogues. Printing of newspapers. | 1962 | 162 | 1 167 654 | 2 916 000 | Indoor climate, lighting, noise, paper dust, isopropanol | Observation; Audit; Risk Assessment; Semi-structured interviews; Focus group interviews; Documents analysis |

# Appendix 11. Measurement Scales of Study Variables

**Appendix 11.** Measurement Scales of Study Variables in employee and employer questionnaires (*selected*) (Composed by the author)

| Code | Statements |
|---|---|
| | ***Employees' involvement*** |
| Involv 1 | Employees participate actively in devising, executing and monitoring safety at work (F10C) |
| Involv 2 | Employees comply with safety regulations (F7, F8) |
| Involv 3 | Employees provide (written) suggestions in event of any deficiencies in working conditions |
| Involv 4 | Employees participate in Trade Union (E1, E2a, E2b, E2c, I01a) |
| Involv 5 | Importance to be informed and involved for the employees (F1, F2, F11, F12, I01B, I01C) |
| Involv 6 | Employees participation in management decision making process about working conditions and work organization (F8, F9) |
| Involv 7 | Employees participate actively in discussing working conditions, OH&S, work organisation and training with managers and worker's representatives (F8, F10, I9, I10) |
| | |
| | ***Information dissemination/ Communication in safety and prevention*** |
| Info 1 | Importance to be informed (F1, F11, G1) |
| Info 2 | The way how information is disseminated / the possibilities for information dissemination (F7) |
| Info 3 | There is enough knowledge and skills for the performing tasks (YEL21, J11) |
| | |
| | ***Occupational health and safety, preventive planning (working conditions, risk assessment, health promotion, responsibilities*** |
| OHS 1 | Importance of the safe work place for employees (G1) |
| OHS 2 | Occupational Health Services provision to employees (G15, G16, J17) |
| OHS 3 | Health promotion (G18, J18) |
| OHS 4 | Evaluation of the employees' health (YG1, YG2, J16) |
| OHS 5 | Work organisation (B18A, B18B, B18D, B19A, B18C, B20, C10-11, C 25) |
| OHS 6 | Firms has system to identify risks in all job positions (RA) |
| OHS 7 | Responsibilities in the field of OH&S (G2, J02) |
| OHS 8 | Prevention plan formulated setting measures to take on basis on risk assessment |
| | |
| | ***Conflict management and relationships at work (8/10)*** |
| Conf1 | Good relationship at work (D1, D2a, D2b, G01) |
| Conf2 | Conflicts and conflict management (D4A, D5 G02, G03, G05) |
| Conf3 | Worker's unequal treatment at work (D6, D7, G04 ) |
| | ***Safety training*** |
| Train 1 | Firm provide safety training and encourage employees to participate (F10F, YEL20, YEL23) |
| Train 2 | Employees given sufficient training possibilities as well as safety courses (YEL22, B16B) |
| Train 3 | Employees awareness about safety hazards (G3, G5, G14) |
| Train 4 | Employees awareness about safety measures (G4, G14, G17) |
| Train 5 | Awareness of employees and employer (J03, J08, J15, G1, G3, G4, G5) |

| Code | Statements |
|------|-----------|
| ***Managers' attitudes*** | |
| Commit 1 | Managers consider that employees' participation, commitment and involvement is fundamental to health and safety activities (F2, F8, F9) |
| Commit 2 | Managers consider training of employees is essential for achieving a safety workplace (J10a, J10c, J10d, J10e, J11) |
| Commit 3 | Managers consider that it is fundamental to monitor and inspect working environment and safety activities(E01, E12a, J13a) |
| Commit 4 | Managers take responsibility for health and safety (J01, J02, J09, G2) |
| Commit 5 | Managers regularly visit workplace to check work conditions or to communicate with employees (J12, J14) |
| Commit 6 | Managers participate in safety meeting with employees to discuss safety matters |
| Commit 7 | Managers participate in safety training and provide it to their employees (J03) |
| ***Work organization , co-worker support(21/11)*** | |
| Org 1 | Importance of the safe work place (E12b, G1) |
| Org 2 | Importance of risk assessment, evaluation of working condition, performing measurements (E10b, E12a, E 12c, J13b, J14) |
| Org 3 | Instruction/ safety training of new workers (E10a, G14) |
| Org 4 | Motivation is essential in order to achieve a good safety performance (E12e, H1, H3) |
| Org 5 | Open discussion in the organization about issues in the field of OH&S (E12f, I01c) |
| Org 6 | Two way communication (I01a, I01b) |
| ***Learning, development possibilities*** | |
| Learn 1 | The organization encourages employees to study, participate in the courses, conference (E12d, J10a, L01, B16b, YEL11, YEL22a, YEL22b) |
| Learn 1 | Team work / collective learning (J10b, B16c, YEL22d) |
| Learn 3 | Given time for communication and learning (L01, YEL 21, YEL23) |
| Learn 4 | Employees help to each other to solve problems in the field of OH&S and thus to learn.(L03, B16c, B32, YEL22e) |
| Learn 5 | Promote cooperation and team learning (L02, B16d) |
| ***Communication in prevention matters*** | |
| Commun 1 | There is a fluent communication embodied and frequent/regular meetings to transmit principles and rules of action (I01c) |
| Commun 2 | Written materials, guidelines is available in order to inform employees about risks associated with their work and safety measure (J07, L04) |
| Commun 3 | Established reporting system (J05, G6, G7) |

# ELULOOKIRJELDUS

## 1. Isikuandmed

| | |
|---|---|
| Ees- ja perekonnanimi | Marina Järvis |
| Sünniaeg ja -koht | 11.11.1975 Viljandi |
| Kodakondsus | Eesti |

## 2. Kontaktandmed

| | |
|---|---|
| Aadress | Akadeemia tee 3, 12618 Tallinn, Eesti |
| Telefon | +372 6203961 |
| E-posti aadress | marina.jarvis@ttu.ee |

## 3. Hariduskäik

| Õppeasutus (nimetus lõpetamise ajal) | Lõpetamise aeg | Haridus (eriala/kraad) |
|---|---|---|
| Tallinna Tehnikaülikool | Oodatav 2013 | Ärikorraldus, filosoofiadoktor |
| Bergeni Ülikool, Norra | 2001 | Tervise teaduse, filosoofiamagister |
| Tallinna Tehnikaülikool | 1998 | Toiduainekeemia ja -tehnoloogia, tehnoloogiainsener |

## 4. Keelteoskus (alg-, kesk- või kõrgtase)

| Keel | Tase |
|---|---|
| Eesti | kõrgtase |
| Vene | kõrgtase |
| Inglise | kõrgtase |
| Norra | kesktase |

## 5. Täiendõpe

| Õppimise aeg | Täiendusõppe läbiviija nimetus |
|---|---|
| Oktoober/Detsember, 2010 | Dr. Petri Nokelainen, Tampere Ülikool, „Scientific Writing", „Quantitative Research Methods", TTÜ, Tallinn |
| Juuni, 2010 | Nordic Institute for Advanced Training in Occupational Health (NIVA), Taani. Kursus: International Course on Safety Research |
| Jaanuar, 2009 | Finnish Institute of Occupational Health, Soome. Kursus: The impact of OSH and OSH interventions on company performance |
| Aprill, 2008 | University of Manchester, The Institution of Occupational Safety and Health, UK. Kursus: Recent Advances In Safety Training |

| | |
|---|---|
| August, 2007 | Nordic Institute for Advanced Training in Occupational Health (NIVA), Taani. Kursus: Safety Climate Concepts and Measurements |
| August, 2007 | Nordic Institute of Advanced Training in Occupational Health (NIVA), Taani.<br>Doktori suvekool (NIVA-NAM): Health Economics and OSH; How to measure Trends in the Working Environment |

## 6. Teenistuskäik

| Töötamise aeg | Tööandja nimetus | Ametikoht |
|---|---|---|
| Alates 2005 | Tallinna Tehnikaülikool | Lektor |
| 2005 -2005 | Eesti Vabariigi Tööinspektsioon | Tööhügieeni peaspetsialist |
| Alates 2004 | Eesti Akrediteerimiskeskus | Assessor |
| 2001-2004 | Töötervishoiu Keskus | Töötervishoiu ja -ohutuse ja tööhügieeni peaspetsialist |
| 1999-1999 | Eesti Vabariigi Tööinspektsioon | Tööinspektor |

## 7. Teadustegevus

### (1) Artiklid rahvusvahelistes ajakirjades või artiklikogumikes (valitud)

**Järvis, M**., Tint, P. 2009. The formation of a good safety culture at enterprise. Journal of Business Economics and Management, 10 (2), 169 - 180.  (ETIS 1.1)

Reinhold, K., **Järvis, M**. and Tint, P. 2009. Risk Observatory - A Tool for Improving Safety and Health at the Workplace. *International Journal of Occupational Safety and Ergonomics*, 15 (1), 101-112.  (ETIS 1.1)

Tint, P., **Järvis, M**., Reinhold, K. and Paas, Õ. 2009. Risk Assessment and Measurement of Hazards in Estonian Enterprises. *Environmental Engineering and Management Journal*. 8 (5), 1165-1170. (ETIS 1.1)

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**Kempinen, M**., Tint, P. 2006. Auditing of safety management system in Estonian medium-scale enterprises. Soares and Zio (Toim.). Safety and Reliability for Managing Risk*. London: Taylor & Francis*, Ltd , 773 – 780. (ETIS, 3.1)

**(2) Artiklid konverentsikogumikes (valitud)**

**Järvis, M.,** Tint, P. 2009. The effects of human resource management practice on development of safety culture. University of Management and Economics, Vilnius Conference proceedings: Insights into the sustainable growth of business. MMRC conference, 19-21 Nov, 2009, Vilnius, CD-ROM: 15 pp. (ETIS, 3.4)

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**Järvis, M.,** Tint, P. 2009. Evidence-Based Development of Safety Culture at the Estonian Enterprises. Radim Bris, Carlos Guedes Soares, Sebastián Martorell (Eds.). Reliability, Risk and Safety. Theory and Applications. London: Taylor & Francis: 1269 - 1276 (ETIS 3.1)

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**Järvis, M.,** Tint, P. 2007. Knowledge management in occupational health and safety: Estonia example. In: Ergonomics in Contemporary Enterprise: 11th Conference on Human Aspects of Advanced Manufacturing: Agilty and Hybrid Automation. 4th Intern.Conf. ERGON-AXIA. (Toim.) Pacholski, L.M.; Trzeielinski, S.. Poola: IEA Press, USA, 2007, 517 - 534. (ETIS, 3.2)

**Kempinen, M.,** Tint, P. 2006. Auditing of safety management system in Estonian medium-scale enterprises. Soares and Zio (Eds.). Safety and Reliability for Managing Risk: 773 - 780. London: Taylor & Francis Ltd (ETIS 3.1)

**Järvis, M**., Tint, P. 2009. Empolyment, cultural differences and work safety: Estonia example. Prof. G.Startiene (Eds.). Economics and management-2009 (111-112). Kaunas: Technologija (ETIS 3.2)

Kurppa, K., Rünkla, E., Tammaru, E. and **Kempinen, M.** 2004. Networking system to strengthen occupational health and safety in Estonia. Suvi Lehtinen (Eds.). Occupational health services in Estonia. Estonian-Finnish Twinning Project on Occupational Health Services 2003-2004. Helsinki : Finnish Institute of Occupational Health: Finnish Institute of Occupational Health, 47 - 52 (ETIS 3.2)

**Kempinen, M.,** Kurppa, K. 2004. Sectoral profile on occupational health and safety in Estonian agriculture. Suvi Lehtinen (Eds.). Occupational health services in Estonia. Estonian-Finnish Twinning Project on Occupational Health Services 2003-2004. Helsinki : Finnish Institute of Occupational Health: Finnish Institute of Occupational Health, 53 - 58 (ETIS 3.2)

**(3) Konverentsi ettekanded: töö tulemused on esitatud 10 rahvusvahelisel konverentsil**

**8. Kaitstud lõputööd**

**Magistritöö**: "Riski hindamine Eesti haigla kirurgiaosakonnas lämmastikugaaside ja formaldehüüdi kasutamisel", juhendaja professor Bente Moen, Bergeni Ülikool, Norra, 2001.

**Bakalaureusetöö**: „Dieettooted ja näidismenüüd tsöliaakiahaigetele", juhendaja Ester Horn, Toiduainekeemia ja –tehnoloogia kateeder, Tallinna Tehnikaülikool, 1998.

**9. Teadustöö põhisuunad**

Ohutuskultuur. Töötervishoid ja tööohutus. Teadmusjuhtumine ohutuses. Töötervishoiu ja -ohutuse juhtimissüsteemid. Tööelu kvaliteet ja heaolu.

**10. Teised uurimisprojektid**
'Keemiatehnilised aspektid keskkonnariskide hindamisel' (kood SF0140022s10)

# CURRICULUM VITAE

## 1. Personal data

|  |  |
|---|---|
| Name | Marina Järvis |
| Date and place of birth | 11.11.1975, Viljandi |

## 2. Contact information

|  |  |
|---|---|
| Address | Akadeemia str 3, Tallinn, Estonia |
| Phone | +372 6203 961 |
| E-mail | marina.jarvis@ttu.ee |

## 3. Education

| Educational institution | Graduation year | Education (field of study/degree) |
|---|---|---|
| Tallinn University of Technology | Expected 2013 | Business Administration, Doctor of Philosophy |
| University of Bergen, Norway | 2001 | Master of Philosophy in Health Science |
| Tallinn University of Technology | 1998 | Master in Foodservice Technology |

## 4. Language competence/skills (fluent; average, basic skills)

| Language | Level |
|---|---|
| Estonian | fluent |
| Russian | fluent |
| English | fluent |
| Norwegian | average |

## 5. Special Courses

| Period | Educational or other organisation |
|---|---|
| October/December, 2010 | Dr. Petri Nokelainen, Tampere University, „Scientific Writing", „Quantitative Research Methods", TUT |
| June, 2010 | Nordic Institute for Advanced Training in Occupational Health (NIVA), Denmark.  Course: International Course on Safety Research |
| January, 2009 | Finnish Institute of Occupational Health, Finland. Course: The impact of OSH and OSH interventions on company performance |
| April, 2008 | University of Manchester, The Institution of Occupational Safety and Health, UK. Course: Recent Advances In Safety Training |

| August, 2007 | Nordic Institute for Advanced Training in Occupational Health (NIVA), Denmark. Course: Safety Climate Concepts and Measurements |
|---|---|
| August, 2007 | Nordic Institute of Advanced Training in Occupational Health (NIVA), Denmark. Doctoral summer school (NIVA-NAM): Health Economics and OSH; How to measure Trends in the Working Environment |

## 6. Professional Employment

| Period | Organisation | Position |
|---|---|---|
| Since 2005 | Tallinn University of Technology | Lecturer |
| 2005 -2005 | National Labour Inspectorate | Occupational hygiene specialist |
| Since 2004 | Estonian Accreditation Centre | Assessor |
| 2001-2004 | Occupational Health Centre | Chief specialist in occupational health, occupational hygiene |
| 1999-1999 | National Labour Inspectorate | Inspector |

## 7. Scientific work

### (1) Articles in international journals or in collection of articles (selected)

**Järvis, M.,** Tint, P. 2009. The formation of a good safety culture at enterprise. *Journal of Business Economics and Management*, 10(2), 169 - 180.  (ETIS 1.1)

Reinhold, K., **Järvis, M.** and Tint, P. 2009. Risk Observatory - A Tool for Improving Safety and Health at the Workplace. *International Journal of Occupational Safety and Ergonomics*, 15 (1), 101-112.  (ETIS 1.1)

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**Järvis, M.,** Tint, P. 2009. Employment, cultural differences and work safety: Estonia example. *Economics and Management*, 14, 567 - 574. (ETIS 1.2)

**Järvis, M.,** Virovere, A. and Tint, P. 2013. Formal Safety Versus Real Safety: Quantitative and Qualitative Approaches to Safety Culture – Evidence from Estonia. *Proceedings of the Latvian Academy of Sciences* (forthcoming, ETIS 1.2).

**Järvis, M.,** Virovere, A., and Tint, P. 2013. Knowledge Management: a neglected dimension in discourse on safety management and safety culture – evidence from Estonia. *Scientific journal of Riga Technical University* (forthcoming, ETIS 1.2)

**Järvis, M.,** Virovere, A. and Tint, P. 2013. Managers' perceptions of organizational safety: implication for the development of safety culture. *Scientific journal of Riga Technical University* (forthcoming, ETIS 1.2).

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**Järvis, M.,** Tint, P. 2009. Evidence-Based Development of Safety Culture at the Estonian Enterprises. Radim Bris, Carlos Guedes Soares, Sebastián Martorell (ed). Reliability, Risk and Safety. Theory and Applications *London: Taylor & Francis*, 1269 - 1276. (ETIS, 3.1)

Paas, Õ., Tint, P., **Järvis, M**. 2009. The assessment of major accident risks in Tallinn (Estonia). *Hazards XXI:* Process Safety and Environmental Protection in a Changing World (CD-ROM) *Symposium Series 155.* Manchester, UK: The Institution of Chemical Engineers, 729 – 738. (ETIS, 3.1)

Tint, P., **Järvis, M.,** Reinhold, K. and Tuulik, V. 2007. Prevention of physiological and psychological stress at workplace. Avem, T.; Vinnem, J. E. (ed). Risk, Reliability and Societal Safety. *London: Taylor & Francis,* 1275 – 1282. (ETIS, 3.1)

**Kempinen, M.,** Tint, P. 2006. Auditing of safety management system in Estonian medium-scale enterprises. Soares and Zio (Toim.). Safety and Reliability for Managing Risk. *London: Taylor & Francis*, Ltd , 773 – 780.  (ETIS, 3.1)

**(2)       Articles in conference presentations (selected)**

**Järvis, M.,** Tint, P. 2009. The effects of human resource management practice on development of safety culture. University of Management and Economics, Vilnius Conference proceedings: Insights into the sustainable growth of business. MMRC conference, 19-21 Nov, 2009, Vilnius, CD-ROM: 15 pp. (ETIS, 3.4)

**Järvis, M.,** Reinhold, K.,Tint, P. 2009. The innovative tools for prevention of accidents in a post-socialist country. Radim Bris, Carlos Guedes Soares, Sebastián Martorell (Eds.). Reliability, Risk and safety. Theory and Applications. London: Taylor & Francis: 25 - 32 (ETIS 3.1)

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Paas, Õ., Tint, P., **Järvis, M**. 2009. The assessment of major accident risks in Tallinn (Estonia). Hazards XXI: Process Safety and Environmental Protection in a Changing World (CD-ROM) Manchester, UK: The Institution of Chemical Engineers, Symposium Series 155, 729 - 738. (ETIS 3.1)

**Järvis, M**., Tint, P. 2008. Knowledge transfer – critical components in occupational health and safety-an Estonian approach. In: Hazards XX. Process Safety and Environmental Protection. Harnessing Knowledge – Challenging Complacency. IChemE: Hazards XX. Process Safety and Environmental Protection. Harnessing Knowledge – Challenging Complacency.Rugby, Manchester, UK: Institution of Chemical Engineers, 385 - 397 (ETIS 3.1)

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**(3)       Conference presentations:  the study results were presented by the author in 10 international scientific conferences**


## 8. Defended theses

**Master thesis**:  "Occupational Health Risk Assessment of Chemical Agents used in a Surgical Department of a Hospital in Estonia", supervisor professor Bente Moen, Bergen University, Norway, 2001

**Bachelor thesis**:  "Compilation of diet and sample menu for people suffering from Coeliac disease", supervisor Ester Horn, Department of Food Processing, Tallinn University of Technology, 1998

## 9. Main areas of scientific work/Current research topics
Safety culture. Occupational health and safety. Knowledge management in occupational health and safety. Safety Management Systems. Quality of working life and wellbeing

## 10. Other research projects
The current project, where I am involved is 'Chemical Engineering Aspects in Environmental Risk Assessment' (code SF0140022s10)

# ACKNOWLEDGEMENTS

I would like to express my thanks to the many individuals who helped in the preparation of this thesis. I hesitate to list all of them because I do not wish to leave anyone out. So let me apologise to all the wonderful people I have missed. That means so very much to me. Thank you--all of you!

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Marina Järvis

# KOKKUVÕTE

## Ohutusteadmiste hindamine ohutusjuhtimises jätkusuutlikkuse tagamiseks Eesti väikestes ja keskmistes ettevõtetes

Teadmistepõhine majandus nõuab organisatsioonidelt pidevat õppimist ja teadmiste täiendamist selleks, et olla jätkusuutlik ja konkurentsivõimeline. Seega on töötajate õppimine ja arendamine iga ettevõtte jaoks võtmeküsimus (Chua ja Lam, 2005). Käesoleva doktoritöö *keskmes* on ohutusjuhtimine, mille defineerimisel lähtutakse Fernández-Muñizi ja tema kolleegide (2009, lk 981) pakutud definitsioonist: "See on integreeritud mehhanism töötervishoiu ja tööohutuse ning seadusest tulenevate nõuete täitmiseks". Töötervishoiu ja tööohutuse efektiivne juhtimine põhineb teadmusjuhtimisel (Sherehiy ja Karwowski, 2006), mis tähendab töötervishoiu- ja tööohutusteadmiste loomist, säilitamist, arendamist, jagamist ning kasutamist oma töötajate jaoks. Ettevõtte töötervishoiu ja tööohutuse tagamine on kompleksne tegevus, mis on seotud ohutusjuhtimisega ja hõlmab nii seadustega määratud ohutusreeglite täitmist kui ka ohutuskäitumise tagamist, ohutuse väärtustamist ning ohutusteadmiste pidevat täiendamist. Hästi toimiv ohutusjuhtimine tagab tugeva ohutuskultuuri, kus töötajad järgivad ohutuskäitumist ja -reegleid (Bently ja Tappin, 2010; Fernández-Muñiz *et al*., 2009). Organisatsiooni ohutuskultuuri ja ohutuse kui väärtuse uurimine võimaldab hinnata ohutusjuhtimise süsteemi ja seda, mis on tööandjatele selles oluline ning millest nad oma otsuste tegemisel lähtuvad. Jagatud väärtused ja tõekspidamised on aluseks käitumismustritele, mis organisatsioonis kujunevad ning määravad töötervishoiu- ja tööohutustegevused. Ohutuse tagamine tehnilise disaini ja materiaalse ressursi/vara juhtimise abil, näiteks ohutu tehnoloogia kasutamine, regulaarne auditeerimine ja põhjalik riskianalüüs, samuti ohutuseeskirjade ja reeglite pidev täiendamine, on endiselt oluline, kuid ebapiisav. Töötervishoiu ja tööohutuse juhtimises on oluline arvesse võtta ka mittemateriaalset ressurssi, nagu inimeste kogemused, teadmised ja oskused, samuti töötajate valmisolek ja motivatsioon neid jagada ning kasutada. Eriline tähtsus on organisatsioonis kogemustel ja vaiketeadmistel (*tacit knowledge*), millest tuleneb kasvav huvi teadmusjuhtimise vastu. Teadmusjuhtimist ohutusjuhtimises on seni vähe uuritud ja on vähe teadmisi selle kohta, kuidas teadmusjuhtimine mõjutab ohutuskultuuri.

Käesoleva uurimistöö probleem seisneb selles, et paljud ettevõtted soovivad parendada ohutust organisatsioonis, kuid ei tea, mil viisil seda teha, ega mõista teadmusjuhtimise ja teadmiste jagamise tähtsust selles protsessis. Doktoritöö *eesmärk* on uurida teadmusjuhtimise rolli ja tähtsust ohutusjuhtimises kui võimalust parendada ohutuskultuuri Eesti väikestes ja keskmistes ettevõtetes. Doktoritöös uuritakse, kuidas juhitakse ohutusteadmiste omandamist ja jagamist ning muutusi ettevõtte ja riiklikul tasandil, samuti analüüsitakse ohutuskultuuri

erinevaid dimensioone ning nende seost ohutusjuhtimisega. Doktoritöö põhineb seitsmel teadusartiklil, mille ühendav teema on ohutuskultuuri parendamine teadmusjuhtimise kaudu ja ohutusjuhtimissüsteemi arendamine.

UURIMISTÖÖ METODOLOOGIA

Uurimistöö eesmärgist lähtuvalt on tegemist avastusliku (*exploratory*) tööga. Käesolev ohutuskultuuri uurimine rajaneb kindlatel filosoofilistel lähtekohtadel. Autor valis sotsiaalse konstruktivistliku (*social constructivism*) uurimistöö paradigma, mis näeb ohutuskultuuri kui sotsiaalselt konstrueeritud mõiste mitmemõõtmelisust ning annab võimaluse mõista paremini ohutuskultuuri olemust ja kontseptsiooni. Töös rakendatav teaduslik meetod (*research approach*) on tõlgendav lähenemine (*interpretive approach*), mis mõistab ohutuskultuuri kui jagatud tähendusi, väärtusi ja käitumismustreid, eesmärgiga ennetada tööõnnetusi ning motiveerida järgima ohutusreegleid ja -eeskirju. Doktoritöö uurimismeetod on uudne panus olemasolevasse kirjandusse, sest ohutuskultuuri ja teadmusjuhtimise kvalitatiivseid uuringuid on vähe, eriti juhtumiuuringute strateegiat kasutades (Glendon, 2008). Uurimistöös rakendatud tõlgendav lähenemine kasutab nii kvantitatiivseid kui ka kvalitatiivseid meetodeid, et uurida, kuidas ohutust väärtustatakse ja juhitakse. Uurimistöö strateegiaks on juhtumiuuring (*case study*), kuna see annab võimaluse säilitada tõeliste sündmuste terviklikkust. Uurimistöö rakendab triangulatsiooni nii andmeallikate põhiselt (ristkontroll informatsiooni kogumisel, kasutades erinevaid empiirilisi allikaid), kombineeritud andmekogumismeetodite kui ka andmeanalüüsi põhiselt.

Töös kasutatakse nii esmaseid kui ka teiseseid andmeid. Põhiuuring toimus 2009. aasta aprillist oktoobrini. Juhtumiuuringuteks valiti kaheksa keskmise suurusega tootmisettevõtet erinevatest majandusharudest: metalli- (3), tekstiili- (2), plastmassi- (2) ja trükitööstusest (1). Peamised andmekogumismeetodid olid poolstruktureeritud (*semi-structured*) intervjuud tippjuhtide (8) ja töökeskkonnaspetsialistidega (8), kaheksa rühmaintervjuud (*focus group*) töötajatega (22) ning küsimustik. Toetavad uurimismeetodid olid dokumentide analüüs, meedia analüüs, vaatlused, ohutusjuhtimise auditeerimine ja töökeskkonna riskianalüüs, mis täiendasid ning kontrollisid intervjuude andmeid. Peale selle uuriti ettevõtte strateegiat, poliitikat, väärtusi, visiooni- ja missioonisõnastusi, mis olid organisatsioonide kodulehekülgedel. Rakendatud kvantitatiivsete meetodite eesmärk oli uurida tööandjate ja töötajate hoiakuid, töötervishoiu ja tööohutusega seotud arusaamu, väärtushinnanguid, informatsiooni kättesaadavust, ohtude teadvustamist ja töötajate kaasatust. Andmetena kasutati Statistikaameti Eestis 2009. aastal tehtud riikliku töökeskkonnaküsitluse tulemusi. Uuring hõlmab valimina 463 tööandjat ja 1757 töötajat. Peale selle kirjeldab *publikatsioon IV* töötervishoiu ja tööohutuse spetsialistide 2002. a ja 2009. a. korraldatud võrdleva longituuduuringu (*longitudinal*) tulemusi.

## PEAMISED TULEMUSED JA PANUS

Uurimistöö võimaldab teha järeldusi ja anda töötervishoiu- ja tööohutusjuhtimise soovitusi nii ettevõtte kui ka riiklikul tasandil. Uurimisprobleem lahendati ja vastati uurimisküsimustele. Käesoleva uurimistöö tulemused võimaldavad läbi originaalsete väljundite parandada ettevõtete ohutusjuhtimist.

Doktoritöö peamine panus on ohutuskultuuri mudeli väljatöötamine, mille originaalsus väljendub teadmusjuhtimise dimensiooni integreerimises ohutuskultuuri mudelisse, mis võimaldab parendada ohutusjuhtimist ja annab võimaluse küsimustiku koostamiseks ettevõtte ohutuse auditeerimiseks ja ohutuskultuuri hindamiseks, ning uue lähenemise esitamist organisatsiooni ohutuse ja ohutuskultuuri hindamiseks.

Ohutuskultuuri muutmine on võimalik õppimise kaudu, hõlmates nii teadmiste jagamist kui ka koosõppimist. Autor soovitab õppimise ja teadmiste jagamise parendamiseks luua õppivad kogukonnad (*Communities of Practice*), mida juhitakse ohutusjuhtimissüsteemi kaudu (*Publikatsioonid IV–VII*). Uurimistöö näitas, millised muudatused on toimunud Eesti töötervishoiu ja tööohutuse süsteemis pärast Euroopa Liiduga ühinemist, tõi välja vajakajäämised ja esitas ohutusjuhtimissüsteemi parendamise võimalused. Autor töötas välja töötervishoiu ja tööohutuse süsteemi muutmise ettepanekud (*Publikatsioonid I, II, IV*). Uurimistöö panus seisneb selles, et tõendati empiiriliselt, millisel tasemel on keskmiste ettevõtete töötervishoiu- ja tööohutusjuhtimine ning näitas reaalse ja formaalse ohutuse erinevust. Lisaks sellele leidis uurimistöö, millised on olemasolevate ohutussüsteemide puudused (*Publikatsioonid II, III, V*). Uurimistöö teoreetiline panus on järgmine: 1) teadmusjuhtimise rolli kontseptuaalne selgitamine ohutusjuhtimises (*Publikatsioonid V, VI*); 2) ohutuskultuuri parendamine intellektuaalse kapitali teooria põhimõtteid kasutades, arendades organisatsiooni sotsiaalset kapitali süsteemse juhtimise abil (*Publikatsioonid V, VII*); 3) töötervishoiu- ja tööohutusjuhtimise uute uurimissuundade avamine, eriti psühhosotsiaalsete riskide juhtimisel ning töötervishoiu edendamisel, keskendudes ohutusteadmiste süsteemi loomisele (*Publikatsioon V*). Uurimistöö üheks panuseks on ka konfliktijuhtimise kontseptsiooni selgitamine juhtimisinstrumendi ja õppimisvõimalusena (*Publikatsioonid V–VII*). Uurimistöö metodoloogiliseks panuseks on ohutuskultuuri uurimine nii kvalitatiivsete kui ka kvantitatiivsete uurimismeetodite kaudu (*Publikatsioonid V–VII*).

Uurimistöö originaalsus seisneb selles, et vaadeldi väikesi ja keskmisi ettevõtteid, mida on nii Eestis ja ka Euroopas vähe uuritud, ning näitab töötervishoiu ja tööohutuse reaalset olukorda, samuti annab seaduste, eeskirjade ning seeläbi ohutuspoliitika muutmise täiendava aluse.

# ABSTRACT

## Assessment of the Contribution of Safety Knowledge to Sustainable Safety Management Systems in Estonian SMEs

Knowledge is considered a significant constituent for organizational performance (Chua and Lam, 2005) and has become a central resource to achieve the goal of occupational health and safety management systems (Sherehiy and Karwowski, 2006). There is a critical and essential link between safety culture and safety management systems (SMS) through shared values and beliefs that guide behavior patterns and health and safety activities in the organization. A strong safety culture is generally considered as a vital condition to well-functioning SMS (Bently and Tappin, 2010; Fernández-Muñiz et al., 2009). Despite the growing interest in knowledge management (KM) studies, only a few studies have been conducted in the field of occupational health and safety (OH&S), furthermore relatively little is known about how organizations influence and deal with the formation of safety culture with respect to KM.

The *aim* of the current doctoral thesis is to contribute to the enhanced understanding of the role and importance of knowledge management to safety management systems as a tool for improving safety culture in Estonian SMEs.

The thesis is a collection of seven original publications. The study scrutinizes safety KM in the enterprise and state levels from the perspective of safety culture.

RESEARCH METHODOLOGY
The current research is *explorative* and aims at providing understanding of the contemporary SMS in the organizations. It discovers and captures realities about SMSs within the context of industrial SMEs by focusing on safety culture elements. *Inductive research was conducted using qualitative case study approaches to explore studied issues based on social constructivism.* Since OH&S is a multidisciplinary and complex field embracing organizational studies and applied research, the present study applied triangulation forms related to the data (cross-checking information by using multiple empirical sources), to multiple methods of data collection (mixed methods) and data analysis (several researchers examined the materials). The empirical study of the dissertation was conducted in eight Estonian SMEs operating in different economic sectors. The most important research methods were semi-structured interviews with senior managers and safety managers (16), eight focus group interviews with employees (22), several on-site observations and evaluation questionnaires. Supplementary methods were analysis of numerous health and safety documents, media analysis, SMS audits and risk assessment, which complement and verify the data collected during the interviews. In addition, companyies' strategy, policy, values, vision - and mission statements were investigated based on the data available from their homepages. The data were also acquired from a

national Work Environment questionnaire survey conducted by Statistics Estonia in 2009, which is a representative survey utilizing employer-employee-linked data. The current survey comprises a sample of 463 employers and 1757 employees who filled the questionnaires and participated in the study. In addition, *Article IV* describes the results from the comparative (longitudinal) studies of OH&S professionals conducted in 2002 and 2009.

THE MAIN RESULTS AND CONTRIBUTIONS
The findings of the current research allow a set of conclusions and recommendations to be made. The problem set by the author is solved; the author has investigated safety KM in the enterprise and state levels from a safety culture perspective. In the research process, new and original results were obtained which enable the improvement of SMS. The present thesis is innovative in several respects. An original contribution in both theoretical and practical terms lies in the following:

The main contribution of the study is the developed and empirically tested innovative conceptual Model of Safety Culture with Knowledge Management Dimensions that incorporates both tacit and explicit safety knowledge and understanding based upon "Communities of Practice (CoP)". The author emphasizes that two main factors in the process of managing of safety knowledge and organizational learning are essential for strengthening and enhancement of SMS: the development of a CoP (gives a possibility for learning and transmitting practical safety knowledge and, thus, for collective learning) and a supportive and harmonized safety culture where knowledge-sharing is valued by everyone in the organization (*Articles IV-VII*). The thesis research sheds new light onto the existing understanding of the current OH&S system and on the changes occurring in this field in the context of Estonian accession to the EU. The author proposes several recommendations for the improvement of the national OH&S system (*Articles I, II, IV*). The dissertation provides conceptual clarification on the role of KM in the field of OH&S (*Articles V, VI*).

The dissertation contributes important empirical evidence on how SMEs address OH&S. Differences in the assessment between 'formal' safety and 'real' safety in Estonian SMEs, indicating some important safety flaws and drawing attention to contextual variables in the development of SMS and improving the safety cultures (*Articles II, III, V*). Another important contribution of the thesis is in providing conceptual clarification on incorporated conflict management as a learning instrument and its possible effect on safety culture and for knowledge exchange (*Articles V-VII*). In addition, the dissertation contributes to theory by opening new research perspectives in the field of SMS and safety research, especially on the management of psychosocial risk, as well as for health and safety promotion within the enterprises (*Article V*). The present dissertation has made also two major contributions to the existing methodology for evaluation of safety culture (*Articles V-VII*).

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