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Knowledge Management – a Neglected Dimension in Discourse on Safety Management and Safety Culture – Evidence from Estonia

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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 a 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 a safety climate and a 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: **Knowledge management, organizational values, safety assessment tool, safety climate, safety culture.**

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 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 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, company's image, organization's resources, way of action and relationships.

Despite the growing interest in Knowledge Management (KM) studies, only a few studies [15-18] have been conducted 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 understanding 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 CoP, through which an organization can grow, learn and develop new intellectual capital.

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 should also mean changes in employees' 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 the 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 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 programs [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 relationships, 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 a safety climate and a 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 the effective and successful managing of health and safety in the organization, little attention has been devoted 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 understanding. Thus, the concept of CoP is important in addressing not merely employees' behavior, 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.

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 lies not exclusively in the possession of management, but is generated in day-to-day practices of task-based tacit understanding of good safety behavior 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 an in-depth study of the impact of Knowledge Management on the development of safety culture processes (see Fig. 2).

The model proposed takes into account the dynamic interrelationships between safety climate, SMS, safety behavior and motivational strategies for safety knowledge exchange within CoP at the enterprise level.

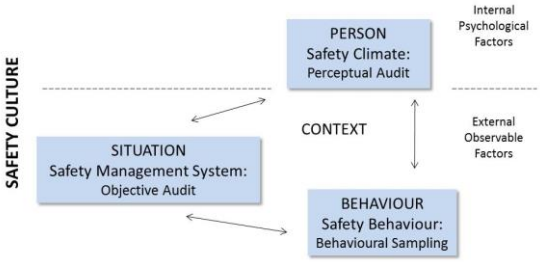

Fig. 1. Reciprocal safety culture model [8].

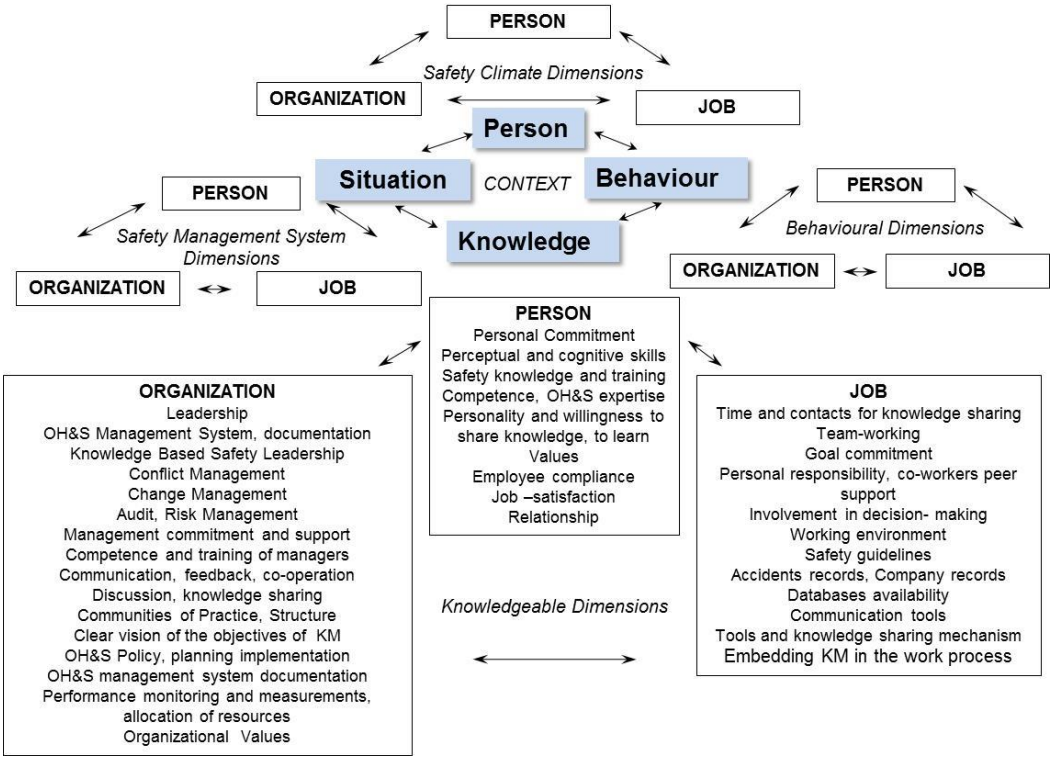

Fig. 2. Reciprocal safety culture model [31].

Thus, the authors suggest 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. The presented reciprocal model provides a comprehensive way of thinking about many processes and aspects that might impact a 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 culture, a reporting culture, a flexible culture 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].

In addition, this model, which served as a basis to develop a questionnaire which when can be used as an effective management tool for conflict management.

The following section provides an overview of the main core constructs of the proposed safety culture model that 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 the 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.

Relationship 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 fills 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 solution strategies. Relationships also include promoting positive working environment, 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 at the organization. The essential aspect is that conflict, like most culturally-based things, must be recognized, acknowledged and 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 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 a good safety climate to be created for informal exchange of safety knowledge.

CoP is implemented in formal 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 [43]. 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 CoP, but their contribution to 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 viewpoints [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 at 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: Ethics and beliefs of people 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 (that 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 define 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 knowledge variable indicate that the four dimensions to measure the overall safety culture of an organization are psychological, behavioral, organizational and knowledge 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 *behavioral* 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 using 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 was 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. Noteworthy 48% have worked at 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 been 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 obtaining 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 'high' and those below 0.4 are '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).

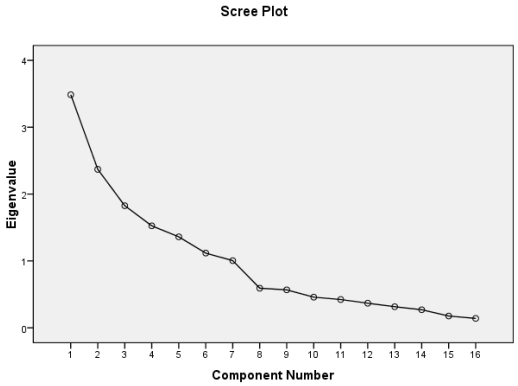

Fig. 3. Scree plot of principal component analysis.

Seven principal components were extracted 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 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 a 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 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 IV

TOTAL VARIANCE EXPLAINED

Item	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	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.

TABLE V

ROTATED COMPONENT MATRIX

	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 knowledge 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. 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 a positive effect on a safety climate. According to the results, hypothesis 1 was not rejected and a 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 have 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 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 claim that "if safety and organizational climate strategically focuses 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 aligned with the goals and commitment of their organization" [61, p. 140].

The current survey suggests that a 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].

TABLE VI

ORGANIZATIONAL ASPECTS OF SAFETY CULTURE

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

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 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 a safety climate. The related factors of this principal component illustrate the relationship between a safety climate and behavioral aspects of safety culture. According to the results, hypothesis 2 was not rejected and a safety climate was established to have a positive impact on the behavioral aspects of safety culture. The current research has demonstrated that the positive safety climate and effective SMS enhance the flow and exchange of knowledge between people and thus create organizational competence regarding safety. Collective knowledge is fundamental and 'to make information and knowledge flow, the people in the organization must be linked' [64, p.14] and connected in the appropriate organizational structure. In order to achieve an effective and rapid flow of safety information and knowledge and become a 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 to work safely and enhances personal responsibility. This is in line with research results [9]; [51] that under positive employees' perceptions of safety their willingness and likelihood to comply with safety rules and procedures, standards and regulations are influenced. In addition, several researchers pointed to the linkages between safety climate, safety motivation, and safety knowledge and behavior [9]; [65-67]. Furthermore, a positive safety climate contributes to co-workers' peer support for safety and improves relationship and communication between employees and employers, and decreases conflicts at work (Table 7). One explanation could be that a 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 influence compliance with workplace norms and the kind of behavior that is likely to be supported, valued or rewarded in the organization [26]. This relationship between a safety climate and the behavioral aspects of safety culture has also been 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 for 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 adopts 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 an organizational structure allows and enables the exchange of safety knowledge which means an effective control and feedback system. Another central theme identified in relation with behavioral factors contributing to a positive safety culture was employees' 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-worker's 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 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 the improvement of 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 an organization, employees tend to be positive in their attitudes towards safety, they will more likely make suggestions and remarks on improving working conditions and will be less inclined to commit unsafe acts [5]. The effective development of 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 part of SMs and demonstrate managers' commitment.

Safety Climate and Psychological Aspects of Safety Culture

The third principal component is extracted 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.

Results from the current study demonstrated that a positive safety climate was perceived to contribute to the development of creativeness and innovation of employees, as well as assuredness and security regarding the labor 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, p.15], since "creators learn from experience" [70, p.31]. Activities such as working, learning and introducing innovations are closely bound up with each other in a local practice, particularly in the CoP [61].

TABLE VIII

PSYCHOLOGICAL ASPECTS OF SAFETY CULTURE

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 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 a positive impact on employees' job content and task satisfaction	0.857

Studies on organizational cultures have developed a similar concept of 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 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 an organization [77]. Conflict has an important effect on the behavior of organization members and has 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 viewpoints [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 a 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 a safety climate and a 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 conducted that incorporates conflict management as a learning instrument and its possible effect on a 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. Therefore, it is a cross-sectional survey. In this sense, establishing a 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 has revealed findings that have both theoretical and practical significance. The implications that these findings have for both safety culture and organizational science research are of particular importance. The results suggest that the safety climate factors, particularly support, commitment, communication provided by management to employees, make an important contribution to a safety culture.

Future Directions

Future research should focus on the understanding of how organizational values are used in an organization and which factors affect their implementation in an organization. There is a need to conduct a survey where the data set of both employees and employers is 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 among organizational, psychological and behavioral aspects of safety culture. A conceptually innovative Reciprocal Model of Safety Culture with Knowledge

Dimension was proposed, which could allow an in-depth study of the impact of Knowledge Management on the development of safety culture processes, as well as describing the relationship between a 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 a 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 an 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 in order to manage safety, knowledge and conflicts.

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