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Creation of satisfactory safety culture by developing its key dimensions

Sari Tappura *, Aki Jääskeläinen, Julius Pirhonen

Department of Industrial Engineering and Management, Faculty of Management and Business, Tampere University, 33014 Tampere University, Finland

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ABSTRACT

Safety culture is a major factor of safety performance. However, a limited number of studies have been carried out on the formation of safety culture in an organization or on the relationship between the maturity of safety culture and employee satisfaction. This study analyzes the path toward the satisfaction of all employee groups through the maturation of various dimensions of safety culture within an organization. Furthermore, it compares the path between environments with high and low communication. The empirical data was gathered using a survey of employees from two Finnish industrial organizations, at all organizational levels, that received 289 responses. Partial least squares structural equation modeling (PLS-SEM) and group comparisons were utilized to analyze the data obtained. It was found that employees' overall satisfaction with safety culture is mainly affected by employee commitment. Employee commitment, in turn, is heavily dependent on top management commitment, which is mediated by supervisor commitment and safety training. By understanding how safety culture is developed in an organization, more effective paths can be identified to improve safety culture further using the results of a maturity analysis. The relationships identified suggest that individual safety culture dimensions should not be developed separately, as they are all related to each other. Finally, it is found that mature communication may specifically support the commitment of employees even without the commitment of supervisors.

1. Introduction

Within organizations, the general humanitarian, regulatory and economic objectives motivate the development of safety at work (89/391/EEC; Brauer, 2006; Reese, 2011). According to Corcoran and Shackman (2007), safety is a part of organizations' social responsibility and moral obligation, and hence, a positive value for companies. Moreover, it is widely recognized that advanced safety management can lead to financial gain by reducing the costs related to occupational accidents and improving productivity and can even result in a competitive edge (Fernández-Muñiz et al., 2009; O'Toole, 2002; Tappura et al., 2015). While safety culture is commonly acknowledged as a significant indicator of good safety practices, a limited understanding about the connections between the safety culture dimensions remains. This understanding would support efforts to develop safety culture and, accordingly, safety performance further in organizations.

Several studies have shown that there is a relationship between safety culture and safety performance (Carder and Ragan, 2003; Lee, 1998; Stemn et al., 2019; Vinodkumar and Bhasi, 2009). According to a study examining the maturity of the safety culture in the mining industry (Stemn et al., 2019), the mines with lower occupational accident rates had similarly higher scores of safety culture maturity. Safety climate is often regarded as a manifestation of safety culture and directly measurable while safety culture is difficult to measure directly (e.g., Cox and Flin, 1998; Mearns et al., 2003). Safety climate refers to the situation at a specific moment while safety culture refers to more enduring phenomena (Hale, 2000, p. 5). Safety climate scores are even considered as the most important indicators for safety performance by Hoffmeister et al. (2014). Based on a study by Vinodkumar and Bhasi (2009), the safety climate scores had a significant negative correlation with occupational accident rates. Moreover, Haslam et al. (2016) suggested that positive safety climate conception and organizational attitudes are linked with higher self-reported mental and physical health among employees.

During the past decades, safety culture maturity models have been emerged to support the development of safety culture and performance. These models support organizations in identifying targets for improvement and specify the various sub-dimensions of safety culture. In a recent critical review by Goncalves Filho and Waterson (2018), 41 safety culture (or climate) maturity models were identified, and majority of

* Corresponding author at: Centre for Safety Management and Engineering, Tampere University, 33014 Tampere University, Finland.
E-mail addresses: sari.tappura@tuni.fi (S. Tappura), aki.jaaskelainen@tuni.fi (A. Jääskeläinen).

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them measured safety culture maturity at an organization using a survey.

Typically, maturity models define the development of a subject over time using maturity levels and describe related essential attributes characterizing an organization at that maturity level (Goncalves Filho and Waterson, 2018). However, many of the previous safety culture maturity models have not been assessed for reliability or validity and the review did not present detailed measures to evaluate the level of safety culture maturity. Moreover, there is still call for empirical studies applying safety culture maturity models, and analyzing and interpreting data gathered with such models. One of the few examples is the study by Pirhonen et al. (2021) which presented descriptive results of safety culture maturity in an industrial context with a recently developed maturity model.

Although the significance of safety culture has been known for decades, organizations are still stiving to improve safety culture (Fleming, 2007). According to Fleming (2007), the lack of safety culture indicators is a major obstacle to improving safety culture. This could be one standpoint hindering the development of safety culture at organizations. Another reason for this could be that organizations do not understand how safety culture is developed; as safety culture may be defined as a subculture of organizational culture (Reiman and Rollenhagen, 2014), changing it is not as simple as it might sound.

Safety culture maturity models typically divide safety culture into sub-dimensions that are used to obtain an overview of the state of the safety culture in a certain organization. Five of the most common dimensions used in safety culture maturity models are management and supervisor commitment, communication, organizational learning, training, and employee commitment (included, for example, in the models of Gordon et al. (2007), Kirk et al. (2007), Parker et al. (2006), Reiman and Pietikäinen (2010), and Tappin et al. (2015) in Goncalves Filho and Waterson (2018)). The importance of these dimensions for culture development has been highlighted in both safety literature and in organizational culture literature. For instance, the impact of management commitment (e.g., Fernández-Muñiz et al., 2007), supervisor commitment (e.g., Huang et al., 2018), and safety training (e.g., Tappura and Jääskeläinen, 2020) on employee commitment have been validated in many studies. Leadership and communication have also been recognized as the most critical factors for managing organizational change (e.g., Gill, 2002; Ogbonna, 1992). However, even though the impacts of these dimensions have been studied, there is a gap in the understanding of how these dimensions are connected to each other and how such connections differ in various environments.

To help fill this gap, identifying the relationships between the dimensions will help form a better understanding of how safety culture is fostered in organizations. Based on a maturity analysis, exact development needs can be recognized when the connections between the dimensions are clear. To address the limited number of studies on the relationships between safety culture dimensions, this paper analyzes the relationships between management commitment, supervisor commitment, safety training, employee commitment, and overall satisfaction with safety culture at the organizational level. A safety culture maturity model was used to gather empirical data from two Finnish industrial organizations. The survey was sent to 1,109 employees from all organizational levels, and 289 responses were received. Partial least squares structural equation modeling (PLS-SEM) and group comparisons between high and low communicational environments were then used to determine the links between the safety culture dimensions.

2. Literature review

2.1. Organizational culture

Even though organizational culture has been studied for decades, the definition of *culture* remains ambiguous in the literature. Organizational culture is often referred "the way we do things around here" (Deal and Kenney, 1982; Schein 1992, p. 8–9). There are two board approaches to culture called interpretative and functionalist approaches (Smircich, 1983, as cited in Reiman and Rollenhagen, 2014). Interpretative approaches consider an organization as a culture, whereas functionalist approaches find culture as a variable, something that an organization has (Reiman and Rollenhagen, 2014).

Schein (1985) defined *culture* as "A pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems." Schein (1985) further divided culture into three levels, according to the visibility of a cultural characteristic to an observer:

1. Artifacts (the surface of a culture, such as the language, products, manners, clothing, and symbols)
2. Espoused values (a sense of what ought to be, including beliefs, goals, values, aspirations, and ideologies)
3. Basic assumptions (the deepest level of culture, such as behavior, perception, thought, and feeling)

According to Schein (1985), the third level defines a culture. Organizational culture is about thinking, behaving, and acting in a manner that has turned out functional and it is also taught to new employees. Organizational culture affects the interaction and information sharing between the members of an organization, what issues are considered as important, and how objectives and the methods used to achieve objectives are seen. According to Hofstede (1997, p.182–183), the core of an organization's culture is based on the common interpretation of day-to-day practices. Most cultural approaches admit that there are different types of subcultures (Parker, 2000; Schein, 2004), but their ontological status is sometimes unclear (Reiman and Rollenhagen, 2014).

Changing culture can be rather difficult. However, many models have been suggested to promote cultural change. Critical factors that are needed for cultural change are organizational structures, leadership modeling behavior, information and communication systems, training and orientation, first-line supervisory performance, work-team culture, performance and reward systems, and results orientation (e.g., Gill, 2002; Ogbonna, 1992; Silverzweig and Allen, 1976).

2.2. Safety culture

Safety culture is often perceived as a subculture of organizational culture (Guldenmund, 2000; Reiman and Rollenhagen, 2014). Safety culture deals with the individual and group attitudes, beliefs, values, and behavior regarding occupational safety and health in an organization (e.g., CBI, 1991; Cooper, 2000; Cox and Cox, 1991; Guldenmund, 2000; Hale, 2000; Locke and Latham, 1990; Turner et al., 1989). This definition is used in the present study. Safety culture also affects and is affected by non-safety-related systems and processes in an organization (Cooper, 2000). Despite the considerable number of studies covering the theoretical and empirical viewpoints of safety culture, uniform conception of the definition and assessment of the construct have not been achieved. It is also noteworthy that several definitions consider safety culture something that the organization *is* rather than *has* (Cooper, 2000).

The concept of safety climate is often used alongside safety culture. Nevertheless, there are differences between the concepts. In terms of safety climate, the emphasis is more on employees' perceptions of safety in an organization (e.g., Byrom and Corbridge, 1997; Cooper and Phillips, 2004; Dedobbeleer and Béland, 1991; Hofmann and Stetzer, 1996; Williamson et al., 1997; Zohar, 2000). Management commitment and employee involvement appear to be the two primary factors in relation to safety climate.

The actual difference between safety climate and culture has been debated in the literature. They have been used interchangeably for too

Table 1
Safety culture dimensions in maturity models.

Category / author	Ashcroft et al., 2005	Parker et al., 2006	Fleming, 2007	Kirk et al., 2007	Gordon et al., 2007	Fleming and Wentzell, 2008	Reiman and Pietikäinen, 2010	Law et al., 2010	Goncalves Filho et al., 2010	Vongvitayapirom et al., 2013	Tappin et al., 2015	Jespersen et al., 2016	Jabonete and Concepcion, 2016	Saunders et al., 2017	Σ
Communication	x	x	x	x	x		x	x	x	x	x		x	x	12
Organisational learning	x			x	x	x	x	x	x	x		x	x		10
Management / supervisor commitment	x	x	x	x	x		x			x	x		x	x	10
Training	x	x	x	x	x	x	x	x		x	x		x		11
Employee commitment & involvement		x	x		x		x		x	x	x			x	8
Reporting	x	x				x		x	x	x	x		x		8
Teamwork	x			x	x		x	x				x	x		7
Rules and procedures		x	x		x					x	x			x	6
Investigation of incidents	x	x	x	x							x		x		6
Performance measurement and rewarding		x	x			x				x					4
Planning and goal setting		x			x		x			x					4
Health, safety and and environment & productivity		x			x					x					3
Contractor/ supplier/ stakeholder management		x			x					x					3
Working under pressure						x					x			x	3
Audits & benchmarking		x			x					x					3

long, which has led to misunderstanding (Hopkins, 2006; Mearns and Flin, 1999). Some authors have seen safety climate as the visible features of safety culture, which are determined by the perceptions and attitudes of employees at a particular moment (e.g., Cox and Flin, 1998; Mearns et al, 2003). Sometimes the term safety climate is seen as a subordinate term of safety culture, and hence it could be used as an indicator of the safety culture, which is difficult to measure (Mearns et al., 2003). According to Singh and Verma (2020), the most typical leading safety indicators in manufacturing companies are safety climate and culture.

Safety culture is commonly perceived as a practical construct for developing safety in spite of the theoretical vagueness and confusion of the concept. Research and development related to safety culture have been carried out in many safety-critical industries, for example, in nuclear power production, aviation, petrochemical sector, maritime, railways, mining operations, and peacetime military operations (Boughaba et al., 2014; Reiman and Rollenhagen, 2014).

2.3. Safety culture dimensions

The identification of safety culture dimensions has been widely studied in the safety field, but there are many varying views on the dimensions. Sometimes the dimensions are categorized in a more general way, describing few dimensions, for example employees' views on managers' commitment to safety, risks at work, and the organization's safety management system (e.g., Clarke, 2000). Sometimes the dimensions are categorized in greater detail. Guldenmund (2007) divided safety culture into nine dimensions that could be considered at the organizational, group, and individual level. To be able to measure safety culture, the definition of the different safety culture dimensions is required.

To identify the most common safety culture dimensions, several safety culture maturity models were assessed. Recently, Goncalves Filho and Waterson (2018) reviewed 41 publications presenting maturity models of safety culture. They analyzed the reliability and validity of the models and found that 12 of these models featured an assessment of reliability or showed at least some validity (i.e., content, face, convergent, or discriminant validity). In the present study, these 12 models—and 2 other relevant models—were assessed to identify the most common dimensions of safety culture (Table 1). The reasons two of the models were not included in Goncalves Filho and Waterson's (2018) review but were included in this analysis are that one was published after Goncalves Filho and Waterson's review and the other could not be found using the term maturity model, as it featured a set of indicators given in a safety culture assessment. The dimensions identified in the 14 included models are not necessarily presented herein using exactly with the same words as those used by the authors of the models, as the dimensions were developed and honed through a content-based analysis synthesizing the reviewed models.

Based on the analysis, the most general safety culture dimensions in the maturity models are communication, organizational learning, management and supervisor commitment, training, and employee commitment and involvement (Table 1). The maturity model applied in this study includes these five most common perspectives of previous maturity models. In the model, employee commitment and involvement are incorporated in the same dimension (employee commitment) since they are closely related in the previous studies. The analysis identified also several other less occurring themes, such as reporting, teamwork, rules and procedures, and investigation of incidents. However, these were not included as separate themes in the applied model as they can be seen as subcategories for the five selected themes.

The nature of the safety culture dimensions identified by the authors also vary; some are tangible, while others are a bit more abstract (Díaz-Cabrera et al., 2007). There are specific questions, such as what kinds of rules and procedures are in place. There are also more qualitative questions, such as how committed employees are to safety improvements. Some authors acknowledged this perspective in defining the safety culture dimensions. For example, Reiman et al. (2008) classified the dimensions into three categories, namely psychological dimensions, social processes, and organizational dimensions. The categories include many of the dimensions presented in Table 1, but they highlight the different natures of the dimensions. It is still more common to have a list of dimensions that has not been further divided based on the nature of the dimensions.

While the safety culture concept and its dimensions are somewhat clear, only a couple of studies have researched the relationships between these dimensions (e.g., Boughaba et al, 2014; Cheyne et al., 1999; Fernández-Muñiz et al., 2007). The studies focused on analyzing the impact of different dimensions—for example, on employee commitment or safety performance (e.g., Huang et al., 2018; Ricci et al., 2016). This study analyzes the relationships between the dimensions to develop a more comprehensive understanding of the construct of safety culture.

In addition to analyzing the links between the dimensions of safety culture, this study seeks to gain further insight into the development of safety culture by analyzing how satisfied the employees of an organization are with the current safety culture. Measuring satisfaction alongside performance has been successfully carried out in maturity models related to performance measurement (Jääskeläinen and Roitto, 2015; Jääskeläinen et al., 2020). Measuring satisfaction besides the state of safety culture has a few benefits. First, more detailed development needs can be identified by measuring satisfaction as well as performance. Although current practices are not very advanced, the respondents might be satisfied with them anyway, and development activities can be targeted to more relevant areas. Second, by having overall satisfaction as a separate dimension, it is possible to identify the dimensions that have the strongest relationship with overall satisfaction. This reveals which of the dimensions are the most important to develop to achieve a satisfactory safety culture.

3. Hypotheses

Many studies have highlighted the impact of management commitment on employee attitude and on behavior related to safety (e.g., Cohen, 1977; Fernández-Muñiz et al., 2007; O'Toole, 2002; Simonds and Shafai-Sahrai, 1977). In addition, the literature has highlighted the importance of supervisor commitment (e.g., Huang et al., 2018; Kapp, 2012; Michael et al., 2006) and safety training (e.g., Fang et al., 2015; Ricci et al., 2016; Robson et al., 2012; Tappura and Jääskeläinen, 2020) for fostering the commitment of employees. As management commitment affects both supervisor commitment and safety training (Simard and Marchand, 1995), it can be argued that the impact of management commitment on employee commitment is mediated by these two factors. Hence, the first hypothesis is proposed:

H1: Management commitment relates positively to employee commitment, but it is mediated by a) safety training and b) supervisor commitment.

The training of employees is not only the responsibility of managers but also of supervisors. Supervisors are typically responsible for the practical implementation of safety-related activities, including training, and new safety instructions and plans become effective only when supervisors get completely involved (Fang et al., 2015). Studies have shown that in addition to designing and delivering training, supervisors' commitment prior to, during, and after training also influence the application of training in work contexts (Lancaster et al., 2013; Freitas and Silva, 2017). Thus, as the commitment of supervisors influences the quality, implementation, and results of training, the second hypothesis is proposed:

H2: Supervisor commitment relates positively to safety training.

None of the previous studies that have measured safety culture have reported how satisfied employees are with the current safety culture in

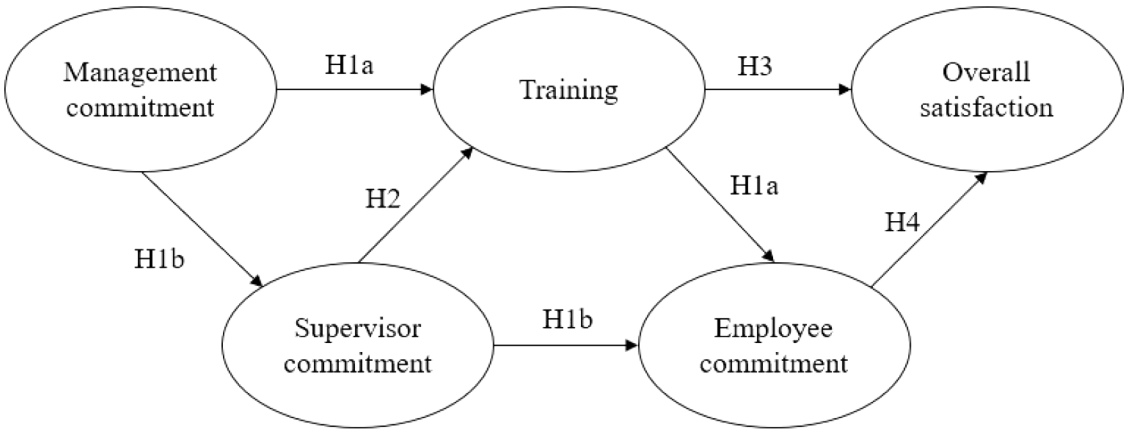

Fig. 1. The research model.

their organizations. However, a recent maturity analysis related to safety performance measurement indicated that the more advanced the safety performance measurement practices were, the more satisfied respondents were with the state of the organization's safety measurement culture (Jääskeläinen et al., 2020). Thus, the employees' overall satisfaction with an organization's safety culture is likely related to the level of the safety culture. As more advanced safety culture practices correlate with safety performance (e.g., Stemn et al., 2019), the overall satisfaction of employees should also correlate with the safety performance of the organization. Studies have indicated that safety training can enhance safety performance (e.g., Burke et al., 2011; Hinze and Gambatese, 2003; Tappura et al., 2021). In addition, safety training has been identified as major management practices predicting safety-related knowledge, motivation, compliance, and participation (Vinodkumar and Bhasi, 2010). As safety performance, knowledge, motivation, compliance, and participation can be seen as antecedents to satisfaction, the third hypothesis is proposed:

H3: Safety training relates positively to overall satisfaction.

Vinodkumar and Bhasi (2009) revealed that satisfaction with safety activities was higher in workplaces where accident rates were lower. The results of Wachter and Yorio (2014) suggested that there is a significant negative relationship between employees' emotional and cognitive engagement, and accident rates. Thus, the commitment of employees to safety is crucial for achieving high levels of safety (e.g., Biggs et al., 2013; Vinodkumar and Bhasi, 2009). Further, because the behavior of employees can significantly affect the overall safety performance, it can be assumed to significantly affect overall satisfaction as well. Therefore, the fourth hypothesis is proposed:

H4: Employee commitment relate positively to overall satisfaction.

Fig. 1 provides a summary of the model that will be tested in the empirical data analysis section of the study. Furthermore, to the constructs included in the Fig. 1, this study includes moderation analysis with group comparisons of the model to include communication in the analysis, as a widely acknowledged element affecting safety culture. Although not part of the hypothesized research model, this additional analysis enables the comparisons of the findings in environments with high/low communication.

4. Materials and methods

4.1. Empirical data

The empirical data was gathered through an electronic survey sent to employees at two Finnish industrial companies, one operating in the infrastructure building industry and the other in the chemical industry. The former company has approximately 1,300 employees, and the latter has 200 employees. The survey was sent to 1,109 respondents, and it received 289 complete answers, yielding a response rate of 26%. Most of the employees from both organizations participated in the study.

Table 2
Respondent profile; % represents the percentage of all responses.

Organization	Responses	
Company 1	252	87%
Company 2	37	13%
Work experience with present employer (in years)		
Less than 1	45	15%
1–3	54	19%
3–5	28	10%
5–10	23	8%
More than 10	139	48%
Work description		
Top management	10	3%
Middle management	41	14%
Supervisors	60	21%
Safety experts	9	3%
Administrative employees	28	10%
Blue-collar employees	141	49%

The largest respondent group was blue-collar employees (later referred as employees), followed by supervisors. Administrative employees, safety experts, middle management, and top management formed the other notable respondent groups. The majority (56%) of the respondents had worked for their present employers for more than 5 years. Table 2 presents the profiles of the respondents.

The respondents gained access to the survey for two weeks, and two reminders were sent during this time. Non-response bias was tested on three groups of respondents: those who had responded at the initial invitation, first reminder, and second reminder (Leslie, 1972). No statistical differences between the respondent groups in the mean variables of the research constructs were found. Hence, non-response bias should not be a concern in the study. In general, the respondents thoroughly answered the questions throughout the whole survey, although there were no compulsory questions in addition to the background questions. The average response rate to each question was 97%.

4.2. Measurement of research variables

To measure safety culture, the study utilized a safety culture maturity model developed based on the recent review of previous safety culture maturity models by Goncalves Filho and Waterson (2018). The model was constructed of fourteen previous safety culture maturity

Table 3
Characteristics of the data.

Construct	Mean (SD)	1.	2.	3.	4.	5.	6.
1. Management commitment	2.95 (0.77)	1					
2. Supervisor commitment	2.71 (0.75)	0.620	1				
3. Training	2.51 (0.75)	0.627	0.638	1			
4. Employee commitment	2.69 (0.57)	0.570	0.653	0.674	1		
5. Overall satisfaction	3.53 (0.66)	0.593	0.657	0.684	0.704	1	
6. Communication	2.76 (0.70)	0.514	0.562	0.637	0.562	0.590	1

All Pearson's correlations are significant at the level of 0.01 (two-tailed).

models that had been assessed for reliability or validity, and the most frequently recurring themes and evaluation criteria were identified from the models (see Table 1). The model was preliminary tested by four company representatives from the intended population and two fellow scholars who evaluated the model and questionnaire. Finally, a revised survey instrument was tested with two persons from the intended population. The model has five key dimensions: communication, training, organizational learning, management and supervisor commitment, and employee commitment. The status of the safety culture was then assessed using written evaluation criteria, presenting four maturity levels (1 = lowest level and 4 = highest level). Written descriptions were used because they can improve objectivity and justify the choice of response options (Cocca and Alberti, 2010; Jääskeläinen and Roitto, 2015). In addition, respondents' satisfaction in relation to each dimension was measured using a five-point Likert scale, since it is highly subjective and difficult to measure with written maturity descriptions. Both scales are in line with previous maturity models for performance measurement (Jääskeläinen and Roitto, 2015; Jääskeläinen et al., 2020).

In order to investigate the research model of this study (see Fig. 1) and apply the PLS methodology of this study, certain changes to the original constructs of the maturity model were required. This study separated management and supervisor commitment into two constructs. This enabled a more detailed information on the relationships between the dimensions, which were observed to have a different status. In addition, to avoid complexity of the structural model the dimension of management communication was excluded. Communication has already received notable research attention in relation to safety culture and its importance is widely accepted (e.g., Vecchio-Sadus, 2007). However, communication was included as a moderating variable for a further analysis to interpret the results in the light of different levels of communication. Furthermore, organizational learning was excluded from the original maturity model since it did not form a statistically valid research construct with the available data. Thus, the resulting dimensions for PLS analysis were management commitment, supervisor commitment, training, employee commitment, and overall satisfaction. In addition, communication was incorporated in the further group comparison analysis. The measurement items and scales are presented in Appendix A.

Management commitment measures the extent to which those in management see themselves as responsible for the established practices to prevent the accidents. In the end, as an employer representative management is responsible for preventing all the accidents that happen in an organization, and this should be clear to both management and employees. Management commitment was measured with four items. The items and scales were adapted from Parker et al. (2006), Gordon et al. (2007), and Hale et al. (2010).

As supervisors interact with employees more often than management do, the actions of supervisors regarding safety play a major role in supervisor commitment. Supervisors should be visibly involved in safety activities and should also develop their skills in relation to safety supervision. Supervisors are the ones who can intervene and give feedback when safety is not considered or when the safety behavior being exhibited is good. Supervisor commitment was measured with two items. The items and scales were adapted from Fleming (2007) and Reiman and Pietikäinen (2010).

Training represents not only how advanced and systematic the safety training given to employees is but also the attitudes of supervisors and employees toward safety training. The attitudes of both the supervisors and employees have an impact on how much the training is valued and, thus, on how the skills acquired are then implemented in the actual work. Training was measured with four items. The items and scales were adapted from Fleming (2007), Parker (2006), Gordon et al. (2007), and Reiman and Pietikäinen (2010).

Employee commitment represents the overall attitudes toward safety among the employees as well as the actions employees take to improve safety in the workplace. These attitudes indicate how safety is viewed in the organization: is it the responsibility of individuals or is it a common goal the development of which is a team effort? The actions represent how employees' attitudes are realized in everyday work—for example, do all employees report all unusual events and follow the safety guidelines even under pressure? Employee commitment was measured with five items, which were adapted from Parker et al. (2006), Goncalves Filho et al. (2010), Gordon et al. (2007), and Saunders et al. (2007).

To measure the respondents' satisfaction with the specific dimension in general, a supplementary item was added to the end of each dimension. Overall satisfaction represents the mean scores of the employeeś satisfaction scores. Satisfaction was measured as a predictor of good performance, similarly as in earlier maturity-model related analysis (Jääskeläinen and Roitto, 2014; Jääskeläinen et al., 2020). Perceived satisfaction can be regarded to indicate the tendency to implement purposeful actions (Gelderman, 1998; Jääskeläinen and Roitto, 2015) which fit into the context-specific needs and objectives. This reflects the idea that performance is a context-specific phenomenon.

4.3. Analysis methods

The statistical software IBM SPSS Statistics 27 and SmartPLS 3.0 were used. PLS-SEM is a component-based analysis method. It supports the purpose of this study in predicting and explaining variance in safety performance (cf. Reinartz et al., 2009). PLS was used for the following reasons. First, when the objective of the research is prediction rather explanation, and theory development rather than testing old theory, PLS-SEM is the suitable method to use (Hair et al., 2011; Shmueli and Koppius, 2011). As the aim of this research was to create new theory about how a satisfactory safety culture is achieved and about the predictive power of different dimensions of safety culture, PLS-SEM was the natural choice. Second, PLS-SEM contains less limiting data-related assumptions and the constructs' measurement properties compared to covariance-based structural equation modeling (CB-SEM); further, it enables researchers to work with more complex models (Hair et al., 2011). Because the data in this study was not normally distributed, some of the latent variables had only a few items, and the model was somewhat complex, potential problems were avoided through the use of PLS-SEM. Last, PLS-SEM analysis contains a rigorous testing of both the measurement and structural models, which enhances the validity and reliability of the constructed model.

A bootstrapping technique was used with 5,000 rounds. Table 3 summarizes the data characteristics (including correlations, means, and standard deviations [SDs]) in the main research constructs. It should be

Table 4
Descriptive statistics of the research constructs.

Construct	Average	Median	Percentage of level 1	Percentage of level 2	Percentage of level 3	Percentage of level 4
1. Management commitment	2.95	3	4.8	16.3	44.3	34.6
2. Supervisor commitment	2.71	3	4.3	23	48.9	23.8
3. Training	2.51	2.5	8.8	32.3	47.6	11.3
4. Employee commitment	2.69	2.8	3.3	32.3	56.7	7.7
5. Communication	2.76	3	7.7	19.4	61.5	11.4

Table 5
Relationship between management commitment and supervisor commitment.

Antecedent	PLS-SEM analysis results					Conclusions
	β	VIF	t-value	Significance (p-value)	F^2	
Management commitment	0.626	1.000	16.339	0.000	0.646	First part of H1b supported
R^2	0.392					
Q^2	0.312					

Table 6
Antecedents to training.

Antecedent	PLS-SEM analysis results					Conclusions
	β	VIF	t-value	Significance (p-value)	F^2	
Management commitment	0.371	1.646	6.367	0.000	0.160	Second part of H1a supported
Supervisor commitment	0.393	1.646	6.817	0.000	0.179	H2 supported
R^2	0.475					
Q^2	0.283					

Table 7
Antecedents to employee commitment.

Antecedent	PLS-SEM analysis results					Conclusions
	β	VIF	t-value	Significance (p-value)	F^2	
Supervisor commitment	0.364	1.643	7.081	0.000	0.176	Second part of H1b supported → H2b supported
Training	0.453	1.643	9.949	0.000	0.274	Second part of H1a supported → H1a supported
R^2	0.544					
Q^2	0.314					

noted that overall satisfaction had a scale ranging from one to five, whereas the scale of other constructs ranged from one to four.

According to Harman's single-factor test, none of the factors covered more than 50% of the data variance indicating the absence of common method bias (Fuller et al., 2016). Variance inflation factor (VIF) values above five are indicators of probable multicollinearity issues; ideally, VIF values should be lower than three (Hair et al., 2019). As the VIFs of the model were clearly below the threshold (the highest VIF being 1.86), it can be concluded that common method bias and multicollinearity are not likely to create challenges for the analysis (see Tables 4–7 in the Results section).

All the measures are reflective which should be tested for reliability, internal consistency, convergent validity, and discriminant validity (Hair et al., 2019). The reliability and internal consistency were tested using indicator loadings and construct reliability (CR). All the items had loadings above the threshold of 0.7, except one (0.628) which can still be regarded as satisfactory (Hair et al., 2019; Hulland, 1999). and all the constructs had CRs between 0.80 and 0.92 (see Appendix B), suggesting that the reliability is good (Nunnally, 1978). Convergent validity can be tested using the average variance extracted (AVE), which should be higher than 0.5 (Hair et al., 2019). All the AVEs exceeded 0.5 (see Appendix B). Discriminant validity was measured with hetero-trait–monotrait (HTMT). HTMT values under 0.85 have a high discriminant validity (Hair et al., 2019), which was also the case in all constructs of this study.

5. Results

5.1. Descriptive analysis

Descriptive analysis was conducted to gain an overall view of safety culture and its measured sub-dimensions. In addition to means and medians of the constructs, the distribution of results was calculated by dividing the observations in individual constructs into four groups as follows: Level 1: 1–1.49, Level 2: 1.5–2.49, Level 3: 2.5–3.49, Level 4: 3.5–4. Percentages of these four groups are presented in the Table 4.

It can be seen that the highest observed status is in management commitment, where around 35% of the responses report the highest level 4 and 79% either level 3 or 4. Clearly the lowest status seems to be in the level of safety training where around 41% of the respondents report the levels 1 or 2. Second lowest status can be observed in employee commitment where around 36% of the respondents report the levels 1 or 2. Blue collar workers were most critical towards the level of safety culture while safety experts and senior managers typically gave the most positive evaluations for the different dimensions of safety culture.

5.2. PLS analysis

As hypothesized, there is a strong relationship ($\beta = 0.626$) between management commitment and supervisor commitment. The presence of this relationship means that the first path for H1b is supported. The F^2

Table 8
Antecedents to satisfaction.

Antecedent	PLS-SEM analysis results					Conclusions
	β	VIF	t-value	Significance (p-value)	F^2	
Training	0.384	1.863	6.615	0.000	0.185	H3 supported
Employee commitment	0.441	1.863	7.841	0.000	0.245	H4 supported
R^2	0.573					
Q^2	0.420					

Table 9
Total indirect effect of management commitment on employee commitment through training and supervisor commitment.

Dimension	β	t-value	p-value	Conclusion
Management commitment → employee commitment	0.439	11.258	$p < 0.001$	Total indirect effect is significant

Table 10
Test of the mediation effect of training on employee commitment.

Dimension	Mediator diagnosis of training	β	t-value	p-value	Conclusion
Management commitment	Indirect effect	0.148	4.844	$p < 0.001$	Complementary mediation
	Direct effect	0.145	2.573	$p < 0.05$	
Supervisor commitment	Indirect effect	0.157	5.132	$p < 0.001$	Complementary mediation
	Direct effect	0.307	5.886	$p < 0.001$	

effect size for this relationship is large (cf. Selya et al., 2012). Management commitment explains 39.2% of the variation in supervisor commitment. The Q^2 statistics demonstrate that management commitment has a medium level of predictive relevance for supervisor commitment (cf. Hair et al., 2019). The results explaining the relationship between management and supervisor commitment are summarized in Table 5.

Table 6 provides an overview of the results related to the level of safety training. The status of management commitment and supervisor commitment have significant and similar effects on safety training. Supervisor commitment has a slightly stronger relationship with training than does management commitment, but the difference is small. This result demonstrates that the first path of H1a is supported and that H2 is supported. The effect sizes (F^2) for these relationships are moderate. The model explains 47.5% of the variation in training, and its predictive relevance is medium.

The results explaining employee commitment are presented in Table 7. Both supervisor commitment and training have a positive relationship with employee commitment, but training is the stronger influencer. This result demonstrates that the second path of H1b is supported and, thus, that H1b is supported overall. The second part of H1a is supported as well and, thus, H1a is supported overall. As both H1a and H1b are supported, the results confirm that management commitment relates positively to employee commitment, but it is mediated by training and supervisor commitment. The effect sizes (F^2) for all these relationships are moderate. The model explains 54.4% of the variation in employee commitment and its predictive relevance is medium.

The results explaining the overall satisfaction of the employees are presented in Table 8. As hypothesized, both training and employee commitment are positively related to overall satisfaction. Employee commitment is the strongest influencer of overall satisfaction. This result demonstrates that H3 and H4 are supported. The effect sizes for both paths are moderate. The model explains 57.3% of the variation in employee safety performance, and its predictive relevance is medium.

To further verify the observed mediative roles of supervisor commitment and training in testing H1, a mediation effects of employee commitment were tested as suggested by Hair et al. (2017). First, the possibility of mediation effects was tested through examining the significance of specific indirect effects for the different paths. Second, the reported total indirect effects through training and supervisor commitment were examined (see Table 9). Third, the significance of the direct effects between the studied variables was analyzed to conclude the type of mediation. Tables 10 and 11 report the results. Both the specific and total indirect effects were significant in all cases.

Table 10 shows that training partially mediates the effect of both management commitment and supervisor commitment on employee commitment. Table 11 shows that supervisor commitment partially mediates the effect of management commitment on employee commitment. However, in both cases, the indirect effect of management commitment is higher than the direct effect ($\beta = 0.148$; $p = 0.000$ and $\beta = 0.192$; $p = 0.000$ vs. $\beta = 0.145$; $p < 0.01$), meaning that the mediating effect through supervisor commitment and training is stronger, although there is some direct effect between the constructs. Thus, it can be concluded that H1 is supported. The direct effect, β, of supervisor commitment on employee commitment is almost double that of the indirect effect via training.

Out-of-sample prediction is an integral element of model assessment in PLS-SEM (Shmueli et al., 2019). Q^2predict values are positive for all the items measured in relation to employee commitment (Table 12), indicating predictive power. The model has high predictive power when all its indicators have smaller PLS errors than LM errors, and medium predictive power if the PLS errors are smaller than the LM errors for the majority of indicators (Shmueli et al., 2019). Table 12 results indicate medium predictive power for employee commitment since the PLS errors are smaller than the LM errors for three out of five indicators.

5.3. Analysis of construct relationships in different environments

A further analysis was conducted to see how the widely acknowledged safety culture construct, namely communication, moderate the observed path relationships in the structural model. Two different subclusters of data were created: 1) Environment with high level of communication which consists of 80 responses reporting the level of more than 3 in communication construct; 2) Environment with low level

Table 11
Test of mediation effect of supervisor commitment on employee commitment.

Dimension	Mediator diagnosis of supervisor commitment	β	t-value	p-value	Conclusion
Management commitment	Indirect effect	0.192	5.437	$p < 0.001$	Complementary mediation
	Direct effect	0.145	2.573	$p < 0.05$	

Table 12
PLSpredict assessment of the dimension of employee commitment.

Item	PLS			LM		PLS-LM	
	$Q^2_{predict}$	RMSE	MAE	RMSE	MAE	RMSE	MAE
EMPLC1	0.215	0.710	0.533	0.717	0.543	−0.01	−0.010
EMPLC2	0.175	0.597	0.437	0.603	0.441	−0.01	−0.004
EMPLC3	0.234	0.578	0.474	0.574	0.457	0.00	0.017
EMPLC4	0.136	0.786	0.605	0.797	0.614	−0.01	−0.009
EMPLC5	0.203	0.652	0.546	0.651	0.536	0.00	0.010

EMPLC = Employee commitment
RMSE = The root mean square error
MAE = The mean absolute error

Table 13
Group comparisons of results in four different sub-clusters.

Data sub-cluster	Communication high		Communication low		Full data
Path	β	p-value	β	p-value	β (P-value)
Management commitment → Training (H1a)	0.249	0.009	0.317	0.029	0.371 (0.000)
Training → Employee commitment (H1a)	0.375	0.000	0.218	0.046	0.453 (0.000)
Management commitment → Supervisor commitment (H1b)	0.550	0.000	0.557	0.000	0.626 (0.000)
Supervisor commitment → Employee commitment (H1b)	0.190	0.063	0.423	0.000	0.364 (0.000)
Management commitment → employee commitment (H1 direct impact)	0.238	0.009	0.110	0.295	0.145 (0.009)
Supervisor commitment → Training (H2)	0.431	0.000	0.320	0.033	0.393 (0.000)
Training → Perceived satisfaction (H3)	0.349	0.000	0.232	0.022	0.384 (0.000)
Employee commitment → perceived satisfaction (H4)	0.482	0.000	0.525	0.000	0.441 (0.000)

Insignificant paths marked with red font.

of communication which consists of 77 responses reporting the level of more than 2.5 in communication construct. These observations reflect how the respondents have seen these major constructs in their closest work community. The results are reported in Table 13.

A few notable differences in the results of different sub-clusters can be identified. When comparing the environments with high and low level of communication, supervisor commitment appears as more essential to employee commitment in the situation of low level of communication in the work environment. In turn, management commitment does not suffice in creating employee commitment in the situations of low level of communication. Supervisor commitment is required to compensate the lack of communication.

6. Discussion

Safety culture has generally been identified as a major indicator of safety performance. Nonetheless, organizations struggle to improve the safety culture, although there are numerous indicators for its measurement. The current study addressed this issue by shedding light on how a satisfactory safety culture is formed in an organization. The role of management commitment, supervisor commitment, and training have been highlighted in the literature as affecting employee commitment, and they seem to be the most commonly used dimensions in safety culture measurement. In the current study, PLS-based structural equation modeling (SEM) was used to analyze the relationships between these dimensions.

The results support our hypotheses and the earlier safety culture research. In their study in the manufacturing industry, Cheyne et al. (1999) determined that managers' actions and responsibilities are related to the judgement of organizations' commitment to safety and to the quality of safety training and personal actions. A study by Fernández-Muñiz et al. (2007) found similar relationships between management commitment, employee involvement, and overall safety performance. This study not only supported the relationship between management commitment and employee commitment but also identified the relationship in more detail, as it considered the mediating constructs. The results suggest that the impact of management commitment on employee commitment is mostly mediated by safety training and supervisor commitment. Both training (e.g., Ricci et al., 2016) and supervisor commitment (e.g., Huang et al., 2018) have been highlighted in the safety literature, but they have not been identified as mediators of management commitment.

As employees' behavior is often connected to safety level (e.g., Biggs et al., 2013; Vinodkumar and Bhasi 2009; Wachter and Yorio (2014), it is not surprising that employee commitment had the strongest relationship with overall satisfaction with safety culture. Thus, the results suggest that the most crucial thing in developing safety culture is enhancing the commitment of employees. The model suggested that supervisor commitment and safety training account for up to 54% of the variation of employee commitment; therefore, when planning efforts for safety culture development, the importance of supervisor commitment and training should not be underestimated. The model also had moderate out-of-sample predictive power, which suggests that the relationships identified are generalizable out of the case organizations. Managers' and supervisors' commitment to safety may be promoted by, for example, appropriate safety targets; participative management training; peer, superior, and top management support; and simplified safety procedures and reporting (Tappura et al., 2017).

That being said, the impact of training appears to have an even stronger effect on employee commitment than does supervisor commitment. In addition, training seems to have a strong impact on overall satisfaction. Thus, the importance of safety training and getting both employees and supervisors committed to safety training should not be underestimated. The results support the hypothesized path between supervisor commitment and training. This relationship has not gotten much attention until now, but nonetheless, it is an extremely important relationship. The commitment of supervisors not only has an impact on how advanced the provided training is but also affects the application of the training in the work context.

This study further extends the understanding on the path towards good safety culture by analyzing the moderating role of a well-known building block of safety culture, namely communication. According to our results, communication appears as a characteristic in a work environment which directly supports employee commitment even without

dedicated efforts by supervisors. More specifically, at least to some extent, mature communication techniques and practices may replace the role of supervisors in supporting employee commitment. Hence, investments in communication are a justified choice for senior managers searching for other means to commit employees than the possibly more burdensome efforts of committing supervisors.

Our study adds to the literature also through its methodology. While maturity analyses aiming at structured analysis of different levels of safety culture are available in the literature, data on the maturity of safety culture has been very limitedly used in statistical analysis. SEM was used the first time more than 20 years ago to identify the relationships between the different dimensions of safety culture. However, there is still a still a lack of understanding about how these dimensions are related to each other and how safety culture is developed in an organization. To the best of our knowledge, this is the first study to use PLS to identify the relationships between safety culture dimensions. PLS enables theory development through its predicting power which suits in the context of safety culture which is highly complex and multidimensional. In addition, as demonstrated by this study, PLS enables the comparison of different safety culture environments even when the subsets of data are rather small. Hence, the use of PLS in future studies is highly encouraged.

This study also has limitations that should be acknowledged. Because the data was gathered over a single time period it cannot fully verify causalities between the factors studied. There are many different dimensions of safety culture, and this study analyzed the relationships between only a few of them; many factors contribute to employee commitment other than management commitment, safety training, and supervisor commitment. The data available for this study did not enable the capturing of organizational learning in the analysis. Also, the results are based on only two case organizations, both of which are from Finland, and most of the responses were gathered from one large case company. For this reason, the relationships should be further validated in other organizations and other countries. In addition, in alignment with the employee structure of a typical manufacturing organization, a large portion of the respondents in this study were blue-collar workers. Hence, the results particularly represent their views, which should be acknowledged when interpreting the results. This study incorporated employee commitment and involvement in the same dimension since they are closely related and were loaded into a single construct. In the future studies, these dimensions could be studied as separate constructs.

7. Conclusions

This study elaborates the results of previous safety culture studies and extends the understanding of how safety culture is developed in an organization. Additionally, the results reveal what factors have the strongest impact on the overall satisfaction of employees with an organization's safety culture. The findings support the idea of measuring and analyzing safety culture as a multidimensional concept. The dimensions of culture are connected and understanding these connections can help in analyzing the results of safety culture measurements. The relationships identified herein between the dimensions are mostly based on the answers of blue-collar workers, whose views are often neglected in safety culture research, even though they are the most safety–critical employee group.

Identifying the relationships between different dimensions supports developing organization's safety culture in a few ways. First, understanding the relationships between the dimensions provides a fuller understanding of how safety culture evolves in an organization. Based on the proposed model, it all starts with top management commitment, which drives the commitment of other employee groups. Management commitment has a strong impact on supervisor commitment and training and without management commitment, it is unlikely that an organization can have a mature safety culture.

Second, by understanding the relationships between the dimensions, more effective development endeavors can be designed. For instance, if the aim is to raise employee commitment, then the identified paths for employee commitment should be acknowledged. The results reveal that the direct impact of management commitment on employee commitment is rather small. Thus, when planning development efforts, the state of training and supervisor commitment should be evaluated to identify where management should focus the development activities. However, it is essential to acknowledge the nature of safety culture; it is a subculture of organizational culture, encompassing individual and group attitudes, beliefs, values, and behavior related to occupational safety. It is not something that can be changed in a day with a single training session.

For practitioners, this study identifies concrete paths to improve safety culture in different work environments. Overall, it is demonstrated that safety culture can be improved through committing supervisors and employees. In addition, training is in an important role in supporting the effort of committing employees and also in overall improvement of safety culture. Descriptive analysis shows that companies should still give more efforts in improving their safety training, while the level of senior managers commitment is highest of the evaluated safety culture elements. Practitioners may also use the results in selecting the most powerful ways of improving safety culture in different kinds of work environments. When the level of communication is low, it is essential that senior managers pay attention to the committing supervisors. Otherwise, the successful path towards good safety culture is not likely to occur.

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CRediT authorship contribution statement

Sari Tappura: Conceptualization, Writing -original draft, Writing -review & editing, Investigation, Methodology, Supervision. **Aki Jääskeläinen:** Conceptualization, Funding acquisition, Data curation, Writing - original draft, Writing - review & editing, Formal analysis, Mehodology, Project administration. **Julius Pirhonen:** Data curation, Writing - original draft, Investigation, Formal analysis, Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Measurement scale for the items included in the analysis

See Table A.1.

Table A.1
Measurement scale for the items included in the analysis.

Theme	Item	Evaluation
Management commitment	What causes accidents in the eyes of management	1. Managers believe that accidents are often just the result of careless work or bad luck, and are part of the job. 2. Managers understand that there are a number of different factors affecting accidents. Faulty machinery and poor maintenance are identified as causes as well as people. 3. Managers look at the whole system, including processes and procedures, when considering accident causes. 4. Managers take a broad view, looking at the interaction of systems and people (e.g., human factors).
	Who is responsible for accidents in the eyes of management	1. Managers see the responsibility for accidents as belonging to those who are directly involved. 2. Managers consider the responsibility of the established practices as a factor affecting accidents, but they have no consequences. 3. Managers admit that management must take some of the blame. 4. Managers accept that management is responsible. Managers assess what they personally could have done to prevent the accidents.
	Management's attitudes toward safety	1. Managers consider safety to be an employee responsibility. Lip service is paid by management about the importance of their commitment to safety. 2. Managers are interested in participating in safety-related issues only when accidents occur. 3. The majority of managers are interested in participating in safety-related issues continuously. 4. Managers clearly think safety is an important part of general management.
	Support for changes that might affect safety performance	1. There is a lack of support from the top management, and there is no active safety specialist to drive change. 2. There is a lack of support from the top management, but there is an active safety specialist to drive change. 3. There is at least passive support from the top management and an active safety specialist to drive change. 4. The change is driven by top management, and a safety specialist actively supports change.
Supervisor commitment	Supervisors' active role in safety	1. Supervisors only talk about safety. 2. Supervisors carry out actions specified in formal safety policies (e.g., worksite visits and safety discussions). 3. Supervisors are proactively committed to, and visibly involved in, safety activities. 4. Supervisors' safety activities are evaluated, and supervisors develop their actions from the feedback received.
	Supervisors' commitment to corrective and proactive actions	1. Supervisors do not care if employees do not consider safety and potential risks in their work. 2. Supervisors encourage employees to report deviations, worries, and their own mistakes. 3. Supervisors show concern and intervene if safe work practices are not followed. 4. Supervisors give constructive feedback to employees when they do not consider safety and potential risks in their work. Positive feedback is given about the safety-conscious behavior of the personnel.
Training	Training of employees	1. Employees are provided with task-specific legally required safety training. 2. Employees receive safety induction that includes legislation and company safety policy. 3. Employees are trained in how to participate in safety development, such as identifying hazards, preparing hazard reports, and making conduct observations. 4. Employees are trained to conduct positive safety observations and provide (and receive) feedback.
	Employees' attitudes toward training	1. Training is seen as a necessary evil. Training is attended only when it is compulsory. 2. After an accident there is an increase in the interest in safety training. Interest in training diminishes over time. 3. Employees are interested in attending safety training even when there have not been any unusual accidents. Training needs are sometimes identified by the employees. 4. Employees are proud of their safety expertise. Needs related to safety training and safety expertise are identified by the employees.
	Supervisors' attitudes toward training	1. Employees are assigned to safety activities based on their availability rather than on having relevant training or experience. 2. After an accident, money is made available for specific training programs. The training effort diminishes over time. 3. Supervisors consider it important that the skills of employees are mapped and lots of standard training courses are given. Acquired course knowledge is tested. 4. Supervisors fully acknowledge the importance of tested skills on the job. Attitudes become as important as knowledge and skills. Development is seen as a process rather than a one-off event.
	Systematization of the training	1. There are no clear objectives for the training. Courses are given after an accident without further planning or skill evaluation. 2. There are clear objectives established for training programs, but there is little knowledge about the quality or impact of the training. 3. There is a mechanism in place to ensure that the scope, content, quality, and quantity of the training programs are adequate. 4. After a well-planned and well-executed training program, feedback is gathered from the trainees and is utilized in developing the training program.

(*continued on next page*)

Table A.1 (*continued*)

Theme	Item	Evaluation
Employee commitment	Employees' commitment to and level of care for colleagues	1. "Who cares as long as we are not caught?" is a common attitude. 2. "Look out for yourself" is still the rule. There is a voiced commitment to care for colleagues after incidents, but this diminishes after a period of good safety performance. 3. Pride is beginning to develop, increasing employees' commitment to safety and care for their colleagues, but the feeling is not widespread. 4. Employees' levels of commitment and care for their colleagues are very high. Employees also participate in defining safety standards.
	Employees' attitudes toward safety	1. Employees have no interest in participating in safety development. 2. Employees are interested in participating in safety development only when serious accidents occur. 3. The majority of employees are interested in participating in safety development. 4. All employees are interested in participating in safety development.
	Employees' actions for safety	1. Employees do not engage in safety development activities. 2. Employees are engaged in safety-related activities only via incident reporting. 3. Employees are engaged in all safety-related activities defined by safety policy. 4. Employees proactively contribute to the design, implementation, and measurement of safety-related changes.
	Working under pressure	1. It is common for employees to take shortcuts at the expense of safety under pressure. 2. Employees rarely take shortcuts at the expense of safety under pressure. 3. Employees do not take shortcuts at the expense of safety under pressure but rarely intervene if someone else does. 4. Employees do not tolerate any unsafe behavior, even under pressure.
	How employees feel about reporting safety observations	1. Employees do not want to inform supervisors about any unusual events that occur. 2. The minority of employees want to inform supervisors about any unusual events that occur. 3. The majority of employees want to inform supervisors about any unusual events that occur. 4. All employees want to inform supervisors about any unusual events occur and want to make safety suggestions.
Communication	Management's interest to communicate safety issues with the work force	1. Managers communicate safety issues to employees only after a serious accident. Any interest diminishes over time as thing get "back to normal". 2. Managers do a lot of talking with employees but there are only a few opportunities for bottom-up communication. 3. Managers realize that dialogue with the employees is desirable and so a two-way process is in place. Asking as well as telling about safety issues goes on. 4. There is a definite two-way process in which managers get more information back than they provide. The communication process is transparent.
	Organization's way to share safety related information	1. Safety information is posted on a notice board or on company website. 2. Safety information is shared regularly by safety newsletter or group e-mail. 3. In staff meetings, safety is regularly addressed to generate open discussion about safety. 4. Extensive use of technology e.g. CEO safety blogs. There are both formal and informal communication channels for raising safety concerns in the organization – up to the highest level if necessary
	Attitudes towards safety communication in the organization	1. Safety communication is seen as a waste of time in the organization. 2. Safety communication is recognized to be important by the managers, but the employees are not interested. 3. There is an open channel of communication between managers and the employees, because both of them consider safety related issues relevant. 4. Safety communication is recognized to be important for culture change by the managers and the employees.
Satisfaction (Items measured at the end of each corresponding dimension)		Overall, how satisfied are you with the commitment of management and supervisors to safety development? *Overall, how satisfied are you with the attitudes toward safety-related learning in your organization? *Overall, how satisfied are you with safety training and its requirements in your organization? *Overall, how satisfied are you with the commitment of employees to safety development? *

*Evaluation scale: Likert scale (1–5; 1 = very dissatisfied, 2 = dissatisfied, 3 = neither dissatisfied nor satisfied, 4 = satisfied, 5 = very satisfied).

Appendix B. Measurement dimensions, items, loadings, construct reliability, and validity scores

See Table B.1.

Table B.1
Measurement dimensions, items, loadings, construct reliability, and validity scores.

Dimension	Item	Loading	CR	AVE
Management commitment	What causes accidents in the eyes of management	0.800	0.878	0.643
	Who is responsible for accidents in the eyes of management	0.791		
	Management's attitudes toward safety	0.847		
	Support for changes that might affect safety performance	0.768		
Supervisor commitment	Supervisors' active role in safety	0.894	0.895	0.809
	Supervisors' commitment to corrective and proactive actions	0.905		
Training	Training of employees	0.709	0.861	0.609
	Employees' attitudes toward training	0.792		
	Supervisors' attitudes toward training	0.828		
	Systematization of the training	0.787		
Employee commitment	Employees' commitment to and level of care for colleagues	0.811	0.878	0.592
	Employees' attitudes toward safety	0.796		
	Employees' actions for safety	0.759		
	Working under pressure	0.700		
	How employees feel about reporting safety observations	0.776		
Communication	Management's interest to communicate safety issues with the work force	0.857	0.798	0.572
	Organisation's way to share safety related information	0.628		
	Attitudes towards safety communication in the organization	0.766		
Satisfaction	Overall, how satisfied are you with the commitment of management and supervisors to safety development?	0.863	0.921	0.745
	Overall, how satisfied are you with the attitudes toward safety-related learning in your organization?	0.886		
	Overall, how satisfied are you with safety training and its requirements in your organization?	0.860		
	Overall, how satisfied are you with the commitment of employees to safety development?	0.844		
	CR = construct reliability; AVE = average variance extracted			

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