International Journal of Industrial Ergonomics 41 (2011) 634–646

Contents lists available at ScienceDirect

International Journal of Industrial Ergonomics

journal homepage: www.elsevier.com/locate/ergon

Nordic Safety Climate Questionnaire (NOSACQ-50): A new tool for diagnosing occupational safety climate

Pete Kines[a,*], Jorma Lappalainen[b], Kim Lyngby Mikkelsen[a], Espen Olsen[c], Anders Pousette[d], Jorunn Tharaldsen[e], Kristinn Tómasson[f], Marianne Törner[d]

[a] Division of Safety Research, National Research Centre for the Working Environment, Lersø Parkallé 105, DK-2100 Copenhagen Ø, Denmark
[b] Finnish Institute of Occupational Health, Tampere, Finland
[c] University of Stavanger, Norway
[d] Department of Occupational and Environmental Medicine, University of Gothenburg, Sweden
[e] International Research Institute of Stavanger, Norway
[f] Administration for Occupational Health and Safety, Iceland

ARTICLE INFO

Article history:
Received 8 July 2010
Received in revised form
11 July 2011
Accepted 3 August 2011
Available online 26 August 2011

Keywords:
Safety perceptions
Safety culture
Organizational climate
Factor analysis
Rasch analysis
Multi-national study

ABSTRACT

Although there is a plethora of questionnaire instruments for measuring safety climate or culture, very few have proven able to present a factor structure that is consistent in different contexts, and many have a vague theoretical grounding. The Nordic Safety Climate Questionnaire (NOSACQ-50) was developed by a team of Nordic occupational safety researchers based on organizational and safety climate theory, psychological theory, previous empirical research, empirical results acquired through international studies, and a continuous development process. Safety climate is defined as workgroup members' shared perceptions of management and workgroup safety related policies, procedures and practices. NOSACQ-50 consists of 50 items across seven dimensions, i.e. shared perceptions of: 1) management safety priority, commitment and competence; 2) management safety empowerment; and 3) management safety justice; as well as shared perceptions of 4) workers' safety commitment; 5) workers' safety priority and risk non-acceptance; 6) safety communication, learning, and trust in co-workers' safety competence; and 7) workers' trust in the efficacy of safety systems. Initial versions of the instrument were tested for validity and reliability in four separate Nordic studies using native language versions in each respective Nordic country. NOSACQ-50 was found to be a reliable instrument for measuring safety climate, and valid for predicting safety motivation, perceived safety level, and self-rated safety behavior. The validity of NOSACQ-50 was further confirmed by its ability to distinguish between organizational units through detecting significant differences in safety climate.

Relevance to industry: NOSACQ-50 will enable comparative studies of safety climate between and within companies, industries and countries. It is suitable for research purposes as well as for practical use in evaluating safety climate status, as a diagnostic tool, and in evaluating the effect of safety climate interventions.

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1. Introduction

Occupational accidents give rise to much human suffering as well as high costs for society, companies and individuals. Although in Europe the frequency of occupational accidents decreased steadily over a number of decades (Hudson, 2007), it still constitutes a substantial problem, and in the last two decades the decrease has leveled out (Regeringskansliet, 2006).

In recent years the awareness of the importance for safety performance of organizational, managerial and social factors, has increased. Safety climate, an aspect of organizational climate, offers a route for safety management, complementing the often predominant engineering approach. In addition, safety climate investigations are more sensitive (e.g. multi-faceted) and proactive bases for developing safety, rather than reactive (after the fact) information from accident rates and accident and incident reports (Seo et al., 2004). Although longitudinal studies are still few, there is growing evidence of safety climate as an antecedent of safety performance (Clarke, 2010, 2006a; Pousette et al., 2008; Kuenzi and Schminke, 2009; Nielsen and Lyngby Mikkelsen, 2007; Wallace et al., 2006;

* Corresponding author. Tel.: +45 39 16 52 00; fax: +45 39 16 52 01.
E-mail address: pki@nrcwe.dk (P. Kines).

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doi:10.1016/j.ergon.2011.08.004

Neal and Griffin, 2006; Zohar, 2002). Previous research has, however, largely failed to identify common factor structures in measuring safety climate (e.g. Brown and Holmes, 1986; Dedobbeleer and Béland, 1991; Coyle et al., 1995). Often an inductive rather than a deductive approach has been applied, and factor labeling and item contents are generally inconsistent in safety climate measures (Flin et al., 2000; Seo et al., 2004). Griffin and Neal (2000) stated that for some purposes it may be sufficient to use a global measure of safety climate, but that more specific, first-order safety climate factors will provide more detailed diagnostic information.

In a small number of recent studies, factor structure replication in different contexts has been successfully accomplished. Cheyne et al. (1998) presented a safety climate model based on a study in the British and French manufacturing industry, which comprised shared perceptions of management standards and goals; safety management; workplace hazards; personal involvement (capturing workgroup involvement); and individual responsibility. This factor structure was confirmed in a study of safety climate in the Swedish construction industry (Pousette et al., 2008; Törner et al., 2002). Seo et al. (2004) identified five dimensions of safety climate from their literature review of 16 safety climate scales, namely management commitment to safety, supervisor safety support, co-worker safety support, employee participation in safety related decision making and activities, and competence level of employees with regard to safety. This dimensionality was confirmed through explorative and confirmative factor analyses in two different sub-samples of grain industry workers. These results support the existence of some generic features of safety climate, and further underline the need for building on previous results in questionnaire development. Hale (2000) stated the need for questionnaires that had been systematically refined through research efforts by several research teams. Glendon (2008a) stated that although there is a plethora of instruments for measuring safety climate or culture, further refinements of climate scales and items are needed. The lack of safety climate instruments that have been validated in different contexts motivated the present work.

The aim of the present work was to develop a Nordic questionnaire for measuring safety climate, covering dimensions based on organizational and safety climate theory, psychological theory, previous empirical research, and empirical results acquired through a developmental process. In order to be suitable for comparative studies between nations and contexts, the questionnaire should be found reliable and valid when tested in all five Nordic countries in their respective native languages, initially in the construction industry, but with additional testing in other occupational branches. The questionnaire should also be available in English. It should be suitable for research purposes as well as for practical purposes to evaluate the safety climate standard, pinpoint safety climate areas for improvement, and to evaluate the effect of safety climate interventions.

2. Theoretical framework

2.1. *Safety climate – a perceptual phenomenon*

Organizational climate theory stipulates that organizational climate emerges through individual perceptions of order in the environment, but also through the creation of new order by inference from what is perceived (Schneider, 1975). A drive for the development of organizational climate is, according to Schneider, that people seek information so that they may adapt to and be in homeostatic balance with their environment. Denison (1996) described organizational climate as a shared, holistic, collectively defined social context that emerges over time. Schneider (1975) argued that there is a risk of confusion between perceptions of organizational practices and procedures (descriptive) and reactions to those practices and procedures (affective), and that organizational climate is descriptive rather than affective (p. 464). Cullen and Victor (1993) likewise argued for tapping only perceptions when measuring climate, since climate is a group phenomenon, and by collecting descriptive rather than affective responses, the problem of confounding climate perceptions by individual psychological characteristics and differences is reduced. Undoubtedly, confusion in this respect has for several years negatively affected the progress of safety climate research.

Neal and Griffin (2002) argued that aggregating constructs such as perceptions, attitudes and behavior into a global measure, obscures meaningful relations between these constructs. Clarke (2006b) stated that aggregation of different psychological constructs in safety climate measures, such as attitudes and perceptions, may obscure the relationships with safety outcomes. Clarke (2006b), in her meta-analysis of 19 studies, also found safety perceptions to have greater predictive validity in relation to occupational accidents than did safety attitudes. In addition, Seo et al. (2004) suggested that attitudinal questionnaire items may be more susceptible to social desirability bias than perceptual items. They stated that most definitions of safety climate include the words “shared” and “perceptions”, which implies an emerging general consensus on the definition of the concept. Griffin and Neal (2000) argued that safety climate should reflect the extent to which employees believe that safety is valued within the organization. In line with this they claimed that, for example, ratings of risk level, affective reactions to safety issues, normative beliefs about safety and self-reported safety behavior, are *not* perceptions of safety climate.

Perceived risk level has in previous research been suggested as a dimension of safety climate (Flin et al., 2000). However, literature shows that risk perception is much influenced by a number of individual and personality factors, such as attitudes, perceived control through response-efficacy and self-efficacy, individual risk behavior, optimism bias, stereotyping, etc. (Mueller et al., 1999; Sjöberg, 2000). On these grounds, risk perception was not considered an appropriate indicator of safety climate.

Safety climate may thus be defined as shared perceptions among the members of a social unit, of policies, procedures and practices related to safety in the organization (Neal and Griffin, 2002; Zohar, 1980). We concluded, as a design criterion for the questionnaire, that measures of safety climate should capture shared safety perceptions, and not include other psychological constructs such as safety attitudes. The individual respondent was considered as an observer and rapporteur of the shared perceptual phenomena.

2.2. *Content of safety climate*

Based on theory and empirical results presented below, we concluded that an instrument measuring safety climate should capture perceptions of conditions contributing to individual motivation, as well as conditions influential to relational aspects of occupational safety. The dimensionality of safety climate in the Nordic Safety Climate Questionnaire was construed within this theoretical framework.

2.2.1. *Management safety priority and commitment to safety*

Organizational climate theory suggests that workgroup members form consensual conceptions on expected role behavior, based on perceptions of organizational policy, procedures and practices. This contributes to perceived order, but also to the creation of order by inference from these perceptions. This is part of an organizational sense-making process. However, since people, in order to reduce stress, need to be in equilibrium with their social environment, it also creates a drive to behave in accordance with this apprehended order (Schneider, 1975). From perceptions of organizational policies, procedures and practices, organizational members thus infer the relative value of different organizational goals, such as for example safety performance (Zohar and Luria, 2004). Accordingly, safety behavior may partially be considered contingent on beliefs that such behavior is expected, and will be rewarded in the organization (Zohar and Erev, 2007). As the organizational priorities are largely communicated through the managers, manager behavior would be a main source of information. If managers are perceived to be committed to safety and to prioritize safety in relation to other goals, safe behavior would be expected to be rewarded, and thereby reinforced. From this it may be inferred that safety climate informs the individual on how to behave in order to maximize individual benefit. In this respect, it may be viewed to represent an individualistic perspective.

Top management involvement in safety, and the priority of safety matters, were two of the themes identified by Zohar (1980) in the literature review undertaken to define the first safety climate scale. Brown and Holmes (1986) tested the safety climate questionnaire developed by Zohar (1980), and identified *management concern for employee well-being*, and *management activity in responding to this concern* as two of three factors. Perceptions of management safety commitment and priority have been found to be the most commonly assessed themes in safety climate research (Flin et al., 2000).

We concluded as a design criterion for the safety climate questionnaire that it should assess management safety priority as well as management commitment to safety.

2.2.2. Workgroup safety priority and commitment

Since being in equilibrium with the social environment contributes to a sense of security and reduces stress, shared perceptions of safety being valued and expected in the organization would also contribute to the development of workgroup norms favoring safety. Such norms would cue individual safety behavior, since individuals may expect safe behavior to be socially rewarded by the group. Clarke (2006b), in discussing the results of her meta-analysis of 19 safety climate studies, suggested that individuals feel more committed to the workgroup than to the organization, and hence that the workgroup is most powerful in the socialization of new members. Clarke suggested perceptions of workgroup norms to be highly decisive for group safety climate.

The results of Dedobbeleer and Béland (1991) indicated that safety climate measures should cover conditions regarding management as well as the workgroup. Andriessen (1978) found safety motivation to be strongly determined by leadership and safety standards of the leader, but also by group standards and group cohesion. Group standards and cohesion also determined safety behavior. Similarly, Young and Parker (1999), studying the formation of group climates, found this to be significantly related to group member interaction. Results by Watson et al. (2005) showed that an index of co-worker safety norms was negatively correlated with at-risk behavior. Cheyne et al. (1998), in their study in the British and French manufacturing industry, found that perceptions of workgroup involvement (labeled personal involvement) partly mediated the effect of climate perceptions regarding management, on safety motivation and behavior. These relationships were later given further empirical support in data from the Swedish construction industry (Törner et al., 2002). Tucker et al. (2008) found that the effect of perceived organizational support for safety, on employee safety voice, i.e. the degree to which employees speak out in an attempt to change unsafe workplace conditions, was mediated through perceived co-worker support for safety. Support for specifying safety climate dimensions regarding not only managerial policies, procedures and practices, but also workgroup ditto, has also been presented by Melía et al. (2008). Seo et al. (2004), in their scrutiny of 16 safety climate scales, identified perceptions of co-worker safety support as one of five major dimensions of safety climate covered in previous research.

We concluded as a design criterion for the questionnaire that it should evaluate safety climate dimensions regarding both, but separately, management and workgroup policies, procedures, and practice. We also concluded that safety priority and safety commitment should be assessed regarding both these levels. Norms of risk acceptance may play a negative role in relation to safety priority, and have been claimed to counteract active safety work (Murray and Dolomount, 1994; Pollnac and Poggie, 1989; Törner and Nordling, 2000). We therefore decided to include an assessment of workgroup risk acceptance in the questionnaire.

2.2.3. Learning, communication and innovativeness

Communication and social interaction are necessary means for the creation of social constructs such as organizational climate. Reason (1997) in his description of a desirable informed safety culture, pointed out a learning culture and a reporting culture as two of the four constituting sub-climates. Hofmann and Stetzer (1998) suggested that management encouraging open communication on safety, sends a strong signal on how safety is valued. Jeffcott et al. (2006) stressed the importance of learning for a positive safety culture, i.e. continuously gathering, analyzing and disseminating information in an environment valuing expertise and being based on trust, where operators can identify and are willing to report abnormal events and errors. Communication is thus not merely an exchange of information, but also a prerequisite for learning and for new, innovative ideas to emerge.

Open and frequent communication between management and employees was one of the important safety themes identified by Zohar (1980) in his literature review. Perceived management openness, including a willingness to share ideas and information freely and accurately, is often put forth as an aspect or facet of management quality necessary for the development of trust in management (e.g. Clark and Payne, 1997), a dimension of safety climate discussed further below. Communication should, to be effective, take place not only as an interaction between management and employees – but also between employees.

We concluded as a design criterion for the questionnaire that safety related communication (open and rich), learning, and innovativeness should be assessed.

2.2.4. Management safety justice

Jeffcott et al. (2006) stated that blame may be a barrier to learning, and argued that when accountability and blame are predominant features of the work situation, safety tends to be excessively managed through formal procedures, as a means of self-preservation, resulting in a compliance culture, increasingly prescriptive and inflexible. In such an organization, they stated, application of rules is favored at the expense of problem-solving and ingenuity. Greenberg (1987) found that poor reward for task performance was considered acceptable by those who received it, if the procedure through which the outcome was established, was considered fair. In regards to safety, Weiner et al. (2008) stated that failing to discipline employees who knowingly act unsafely, challenges widely accepted moral principles, just as much as punishing those who make honest mistakes. Reason (1997), who advocated the benefit of an informed safety culture for safety performance, suggested that this requires a culture where people are prepared to report errors. A prerequisite for this is, according to Reason, a just culture which comprises an atmosphere of trust, but where there is a clear line between acceptable and unacceptable behavior (p. 195).

Organizational citizenship behavior (OCB) has been defined as "individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate promotes the effective functioning of the organization" (Organ, 1997, p. 86). Actively taking responsibility for the safety of oneself and others and engaging in safety activities, could well be regarded as an expression of OCB. Organ (1997) suggested the antecedents of OCB to be "dispositions related to conscientiousness" and "any dispositions that can be confidently and empirically tied to a characteristic level of morale in the workplace" (p. 94). Fassina et al. (2008) based on a meta-analysis of 34 studies on the relationship between distributive, interactional and procedural justice on one hand, and OCB on the other, stated that all three justice dimensions correlated with OCB, but that the correlations with interactional (fair treatment by superiors) and procedural justice (fair procedures) were the strongest. It could thus be argued that employee safety responsibility and safety behavior would be positively influenced by management procedural and interactional safety justice, i.e. just treatment and procedures when handling accidents and near-accidents.

We concluded as a questionnaire design criterion that perceptions of management interactional and procedural justice in regards to safety should be included.

2.2.5. Trust in management

The theory of social exchange (Blau, 1986) further emphasizes the relational component of safety climate. According to this theory, behavior from one party benefitting a second party creates a mutual expectation that this will be reciprocated at some future time by the second party performing behavior that benefits the initiator. When managers, representing and communicating the values of the organization are committed to and prioritize employee safety, this signals care of employees' health. This could be expected to contribute to an obligation to reciprocate by employees contributing to organizational safety performance. It could also be assumed to contribute to employees' trust in management, where trust has been operationalized as perceived trustee competence, integrity, and benevolence (Mayer et al., 1995). Burns et al. (2006) argued that supervisors and managers need to demonstrate their commitment to safety to the employees by, for example, taking rapid actions when incident reports are made, since this will support the development of trust in leaders.

Another theoretical concept of relevance here is that of Perceived Organizational Support (POS) (Eisenberger et al., 1986). POS is based on the assumption that "employees in an organization form global beliefs concerning the extent to which the organization values their contributions and cares about their well-being" (Eisenberger et al., 1986, p. 500), and that such beliefs would increase the employees' affective attachment to the organization. Such attachment would, according to Eisenberger et al. (1986), be positively related to the perception that phenomena that benefit the organization also benefit the individual; that people are inclined to make positive interpretations of organizational activities and characteristics; and contribute to the internalization of organizational values and norms. Eisenberger et al. (1986) found that a negative relation between POS and absenteeism was moderated by a social exchange ideology. As this demonstrates caring for workers' health, it may be assumed that POS would also have a positive effect on safety climate – which there is empirical support for. POS and high-quality leader–member relations have been shown to have an impact on workers' safety commitment and safety communication (Hofmann and Morgeson, 1999), on safety climate (Wallace et al., 2006) as well as on lower accident rates (Hofmann and Morgeson, 1999; Wallace et al., 2006).

Mayer et al. (1995) stated that trust encompasses a willingness to take a risk in a relationship, and to be vulnerable to the other party. McEvily et al. (2003) claimed that trust facilitates cooperation and joint problem-solving by increasing openness and knowledge transfer. Cox et al. (2006), discussing trust in high-reliability organizations, concluded that low trust relations can have negative impacts on an effective safety culture. Zacharatos et al. (2005) found trust in management, and safety climate to predict safety knowledge, safety motivation and safety behavior, as well as a lower rate of safety incidents. However, some negative aspects of trust have also been discussed. McEvily et al. (2003) stated that trust may be misplaced, in that the trustee is not necessarily trustworthy. Trust could also be surfeit. McEvily et al. suggested that in situations of change, it may seem essential to both trustor and trustee to smooth over and thus maintain amicable and trusting relations. Another negative aspect stated by McEvily et al. is that trust, as a socially constructed concept, is heuristic and thus provides a "rule of thumb" for how trustworthiness should be judged. This may induce systematic bias and result in faulty judgments. Rich and open communication in the organization thus stands out even more as an essential dimension of safety climate, in order to counteract these potential downsides of trust. Burns et al. (2006) suggested that trust and distrust may be viewed as different constructs, both of which may have a positive impact on safety. This issue is discussed further below.

It was concluded as a design criterion that the questionnaire should assess the employees' trust in management, and trust in management competence was chosen to represent it. However, the complex nature of trust in relation to safety, further stresses the importance of simultaneously measuring safety communication.

2.2.6. Trust in co-worker safety competence

The workforce's perceptions of the general standard of workers' qualifications, skills and knowledge, was one of the six most common themes in safety climate research found by Flin et al. (2000). Co-worker safety competence was also one of the five dimensions of safety climate identified by Seo et al. (2004). As stated above, perception of competence is often suggested as one of the dimensions of trust. The complexity of trust should, however, be kept in mind. As Conchie and Donald (2008) pointed out, if there is blind trust in co-workers, double checking of safety critical tasks may be overlooked, and mistakes may pass undetected. We concluded that the questionnaire should be designed to contain items assessing perceptions of trust in co-worker competence, but once again, the importance of open and rich communication, participation and empowerment (see further Section 2.2.8 Empowerment), in order to counteract the development of blind trust, should be emphasized.

2.2.7. Trust in the general efficacy of safety systems

In the literature review performed by Zohar (1980) to define the dimensions of safety climate, several aspects of the safety management systems of an organization were identified as central themes, namely high status of the safety officer, frequent safety inspections, and the emphasis of safety training. Later, Flin et al. (2000) in their review of 18 safety climate scales identified the perceived importance of adequate safety training, and perceptions of the safety systems (e.g. status/strength of safety officer and safety committee, and contentedness with or confidence in safety policies and arrangements), as central themes. The importance of well functioning safety systems was confirmed in an interview study with first-line supervisors and worker safety representatives in construction work (Törner and Pousette, 2009). It should be emphasized that safety climate is a social construct, and a climate measure of perceptions of safety systems should not be an "audit" on how such systems are implemented in the workplace under study (Hale, 2000), but rather aim at capturing perceptions of the efficacy for attaining a high standard of safety of a systematic approach to safety through well developed safety management systems. It could be argued that including measures of the importance of safety systems and procedures, violates the decision to only comprise measures of perceptions in a safety climate questionnaire. However, by applying a referent-shift format (Glisson and James, 2002), wording items so that the respondent is requested to rate his or her perceptions of the importance attributed to such structures by the group, does *not* tap into individual attitudes, but rather perceptions of policy.

It is important to keep in mind that there is a risk of over-reliance on safety systems in terms of roles, routines etc. for attaining a high safety standard, or complacency due to conviction about the high safety standard of the organization, manifest through its elaborate safety systems. Pidgeon (1998) expanded on this and stated that organizational culture plays an important role for how we structure our understanding of the world, and these understandings help us to acknowledge certain safety issues. At the same time they may turn our attention away from other equally important issues, so that hazards may "incubate" in the organization. In addition, trying to anticipate all possible risks, and trying to prevent them through elaborate safety management systems, may lead to rigid responses rather than resilience when non-anticipated events occur (Conchie et al., 2006; Pidgeon, 1998). This once again points to the importance of learning (e.g. Pidgeon and O'Leary, 2000) and open and rich communication in the organization. Reason (1997) stated that an informed culture in most respects is the same as a good safety culture, and that an informed culture is based on sustaining "an intelligent and respectful weariness" (p. 195). Hale (2000) advocated a creative mistrust in the risk control systems, as one of the dimensions of a good safety culture. He stated that believing that you have the ideal safety culture should be a warning that you don't, and instead it is sound to constantly question the quality of the safety culture. Hale stressed the importance of open communication and reflexivity.

We concluded as a design criterion for the safety climate questionnaire that it should assess perceptions of the efficacy of safety systems, but that this should be assessed together with other aspects of safety climate, as suggested above.

2.2.8. Safety empowerment

One way for managers to convey trust is by empowering the employees. Empowerment is a delegation of power, and as such it demonstrates that managers trust workers' ability and judgment, and that managers value workers' contributions. Empowerment would thus be expected to contribute to POS. In turn, empowerment would further strengthen social exchanges, and in conditions where safety is highly valued by the organization, empowerment would encourage reciprocation and reinforce safety behavior.

Shannon et al. (1997), in a review of ten studies examining the relationship between workplace and organizational factors and injury rates, found that empowerment of the workers and delegation of safety activities, were consistently related to lower injury rates, i.e. the relation was significant in at least two thirds of the studies. In an interview study with first-line supervisors and workers' safety representatives in construction work, one of the main constituents of workplace safety, in their opinion, was cooperation across hierarchical levels and functions, and support for cooperation through empowerment, mutual trust and having a keen ear (Törner and Pousette, 2009). A prerequisite for safety empowerment would be that the manager trusts the employees' ability to competently take part in decisions regarding safety and in dealing with safety. Results of Clarke and Ward (2006) showed a positive relation between management tactics characterized by being consultative, by inspirational appeals and rational persuasion, and a good safety climate and safety behavior. They also found a positive correlation between coalition tactics and safety participation. Clarke and Ward suggested that these types of management tactics have a beneficial influence on perceptions of communication and perceptions of managers' competence in decision making, which supports development of trust and increases safety participation.

It was concluded as a design criterion for the questionnaire that assessment of management safety empowerment and encouragement of employee safety participation should be included.

3. Overall method and material

3.1. Development process and procedures

The Nordic team for development of the Nordic Safety Climate Questionnaire (NOSACQ) consisted of participants from all five Nordic countries. The development work commenced in 2003 and was based on two to four yearly consensus meetings within the development team, where certain main principles and technical outlines for the questionnaire were set. Based on literature, safety climate was defined as a social unit's shared perceptions at a given time of management and workgroup safety policies, procedures and practices. Individual attitudes and behaviors were not considered part of safety climate. The questionnaire would treat the individual as a rapporteur of shared perceptions, i.e. a referent-shift approach would be applied, with items worded "We who work here…" rather than "I…". The instrument was to be tested first in the construction industry. Construction work generally takes place in temporary organizations with an organizational structure and hierarchy centered around the physical structure to be built, and with participation of several different subcontracting companies (Ringen et al., 1995). This implies that the company as such may not be the significant organization to evaluate concerning safety climate, but rather the temporary organization – the work site. This influenced the construction of questionnaire items so that the wording "We who work here…" was chosen rather than "We who work in this company…".

The shared perceptions may concern conditions at either work site level or group level. It was acknowledged that the dimensions of safety climate concerning management may be perceived differently if they concern top management, site management or first-line manager. The initial idea to separately evaluate workers' perceptions of the different management levels for all non-workgroup related dimensions of safety climate was however abandoned, for three reasons. First, workers may have difficulties in distinguishing first-line management from other levels of management when it comes to the climate dimensions under study, and the answers would thus be ambiguous. This consideration was supported by the results of Melía et al. (2008) who in all samples of their study (Spanish, British and Chinese) found a close relationship between employee safety climate ratings concerning top management and supervisors, respectively. The second reason was that safety climate concerns shared perceptions of management practices, rather than ratings of individual managers' behavior. A specific behavior must not necessarily have been observed by each respondent for him/her to have a generalized opinion on management policy and practice. The third reason for not requesting separate evaluations of conditions at different management levels was practical, as the number of items would have doubled or tripled, making the questionnaire unsuitable, at least for practical use. In the questionnaire, respondents are therefore asked how they perceive that safety issues are dealt with by 'managers and supervisors'. It should be emphasized that the questionnaire acknowledges safety climate as a phenomenon influenced by conditions at different hierarchical organizational levels, and it comprises dimensions specifically related to management policies, procedures and practice, as well as dimensions related to workgroup ditto.

Dimensions and facets of safety climate to be included in the questionnaire were selected on the criterion that there should be theoretical or empirical research support for their validity for safety motivation or safety outcome. The questionnaire should be comprehensive enough to cover a sufficient number of such dimensions to effectively be able to evaluate safety climate status in working life.

Suitable items to represent the above described dimensions were compiled from the literature, and additional items were construed when needed. This resulted in an initial 26 items concerning conditions at management level, and 41 items concerning conditions within the workgroup. The workgroup items were tested with regard to face validity, i.e. content consistency with the intended dimensions. Each dimension was defined on a sheet of paper and each item was printed on a card. Six persons, all naïve in relation to safety research, performed the face validity test. Each person was instructed to read the descriptions of the dimensions, and thereafter put each item card on the dimension sheet they found most accurate in relation to the item content. The reason for using naïve persons for this test, rather than safety professionals, was that they better represented the target populations. Percent of correct (as intended) classification was calculated. Average correct classification was 52% with a range from 0% to 100%. 16 items had less than 50% correct classification. These items were scrutinized, some were reworded, some moved to represent another dimension and some items were deleted. The remaining and revised items, i.e. 26 items concerning conditions at management level and 39 items concerning conditions within the workgroup, were used for the first study. Initially the strategy was to randomly mix items concerning different dimensions within the questionnaire, in order to minimize the item context effect (i.e. that item inter-correlation increased due to item proximity). After the factor structure had been established, the strategy of mixing items from different dimensions was abandoned in subsequent studies, in order to aid the respondents in focusing on specific sub-phenomena. In order to minimize response pattern bias due to stereotype response patterns, items with a negative sense (reversed items) were randomly mixed with items with a positive sense. This strategy was maintained.

The questionnaire was developed in English, translated to all five Nordic languages and subsequently translated (by other persons) back into English, to check semantic consistency. In order to ensure that dimensions and facets were sufficiently well represented, each facet of the prototype questionnaire comprised at least four items. A five-step Likert type response format was initially chosen for rating (Likert, 1932) using the terms *Strongly disagree*, *Disagree*, *Neither agree nor disagree*, *Agree* and *Strongly agree*. (Note: from the third study and onwards the response format was changed to four steps, see further below).

4. Development studies

4.1. Study 1

4.1.1. Method and material, study 1

The prototype questionnaire was administered in the construction industry in all five Nordic countries in October 2005 to February 2006. Respondents were gathered at their respective work sites during working hours, and persons representing the research team presented the aim of the study as well as practical matters related to answering the questionnaire. A representative of the research team was present during the entire procedure and available for further questions. Written, informed consent to participate in the study was given by all respondents. Criterion for selecting the target populations was to achieve as much diversity as possible concerning size of company and work site, as well as age and profession, among the targeted construction workers. The sample comprised both blue collar workers (89%) and first-line supervisors (11%). A total of 753 workers from a wide variety of construction trades and sites in the Nordic countries participated in the study (Denmark = 153, Finland = 147, Iceland = 99, Norway = 153, Sweden = 201).

Almost all participants were male (97%), and the average age was 41.1 years (SD = 13.2). The questionnaire covered respondent background data and 65 items intended to measure seven dimensions of safety climate. Measures were also included for validation purposes. One criterion measure regarded *safety motivation*, (13 items, alpha = 0.87 in the present study). The items were derived from three different sources (Lappalainen et al., 2001/2002; Larsson et al., 2008; Nielsen and Lyngby Mikkelsen, 2007). The items covered individual attitudes toward taking personal responsibility and prioritizing safety. A second criterion measure was self assessment of the frequency of four specified types of *safety violations* during the last two weeks (sample item: I have violated safety rules). The answers were later coded into three categories (1: never, 2: 1–9 times, 3: 10 times or more). The four items were averaged to form a safety violation measure. The reliability in the present sample was good (alpha = 0.77).

Initial analysis revealed a tendency for items with positive and negative sense to load in two different factors. This is a measurement artifact which has been described previously (e.g. Podsakoff et al., 2003). Data screening was performed in order to identify respondents with a stereotype response pattern, i.e. those who appeared not to have noticed the reversed items. The mean scores of direct and reversed items and the absolute difference of these means were calculated for each of the seven pages of the questionnaire, for each respondent. If the difference of means was greater than or equal to two score points for any page, the respondent was considered showing a stereotype response pattern, and excluded from the study. Ninety-three respondents with such response patterns were thus excluded, leaving a usable sample of 660 observations.

Management related items and group related items were analyzed separately for theoretical reasons. Confirmatory factor analysis (CFA) was performed using AMOS 7, exploratory factor analysis using SPSS 15, and Rasch analysis using RUMM2020 (rummlab.com). Intra-class correlation (ICC) was calculated based on mean squares from one-way ANOVA. ICC1 (ICC(1,1)), i.e. the reliability of a single rating, and ICC2 (ICC(1,k)), the reliability of the aggregated mean, were calculated according to formulas presented by Schrout and Fleiss (1979). Site level data were calculated for 34 work sites with at least eight observations, using the AGGREGATE command in SPPS.

4.1.2. Results study 1

4.1.2.1. Management related items. One dimension with seven facets (safety priority; safety commitment; follow-through/safety implementation; safety communication; safety participation and empowerment; safety justice; trust in safety competence) was hypothesized regarding assessment of management. A one-factor CFA model showed acceptable fit to the data (Chi-square = 1112.9, df = 299, $p < 0.001$, CFI = 0.88, RMSEA = 0.064). Factor loadings were significant for all items (0.44–0.71), and with the expected sign. Thus, one factor could adequately account for the variation among the safety management items. However, exploratory factor analysis indicated that the dimensionality could be further elaborated. Scree test indicated one factor, but Kaiser's criteria indicated four factors. Inspection of the varimax rotated four-factor solution showed that two of the hypothesized facets, *management safety empowerment*, and *management safety justice*, could be distinguished, besides a *management safety priority, commitment and competence* dimension, comprising two factors representing positive and negative aspects, respectively. These two were combined, since the difference could be attributed to the instrument artifact described by Podsakoff et al. (2003). Subsequently, a three-factor model was tested using CFA (Chi-square = 970.2, df = 296, $p < 0.001$, CFI = 0.90, RMSEA = 0.059). Chi-square difference test showed that the three-factor model was to be preferred to the one-factor model (Chi-square difference = 142.6, df = 3, $p < 0.001$), although the three factors were highly correlated (0.83–0.86). Multi-group CFA and Rasch analysis were performed to test differential item functioning (DIF) between the five countries. This revealed the presence of DIF for some items, but mostly of a low magnitude. However, since there was a surplus of items in the *management safety priority, commitment and competence* dimension, all nine identified DIF items were discarded. Reliability was calculated for the three scales as Cronbach's alpha. The resulting scales from the first study considering management conditions are presented in Table 1. Since empowerment and justice had few items, and consequently somewhat low reliability, five additional items, based on the literature, were construed for use in the second study (Kivimäki et al., 2003; Spreitzer, 1995).

4.1.2.2. Group related items. Six dimensions were hypothesized regarding assessment of the workgroup, namely safety priority; safety commitment; non risk non-acceptance; trust in co-worker safety competence; safety communication, learning, continuous improvement; and trust in the efficacy of safety systems. A six-factor CFA model showed acceptable fit to the data (Chi-square = 1911.0, df = 687, $p < 0.001$, CFI = 0.85, RMSEA = 0.052). Factor loadings were significant for all items, but two items showed low loadings (0.13 and 0.20). These two items were discarded. Remaining items showed sufficiently high loadings (0.35–0.74), and with the expected sign. Some factors had high inter-correlations. The factors workers' safety priority and workers' risk non-acceptance ($r = 0.91$) were therefore collapsed to a common dimension. The factors trust in co-worker safety competence, and safety communication, learning and continuous improvement ($r = 0.89$) were also collapsed due to high inter-correlation. These conclusions were also supported by the exploratory factor analysis. The factor workers' safety commitment showed high correlation with several other dimensions, but since it was not clearly indicated how to deal with this dimension, it was decided to keep it intact for further testing. Exploratory factor analysis revealed eight items with severe cross-loadings in other dimensions than hypothesized. These items were discarded. One item was also discarded due to low factor loading, specifically in the Finnish sample. The resulting four dimensions with 28 items were tested in a CFA model, with the model showing acceptable fit (Chi-square = 1081.4, df = 344, $p < 0.001$, CFI = 0.88, RMSEA = 0.057). Factor loadings were between 0.45 and 0.74. Factor inter-correlations ranged from 0.58 to 0.77, except for workers' safety commitment, which correlated 0.69 to 0.92 with the other factors. Reliability was calculated for the four scales as Cronbach's alpha. The resulting scales from the first study evaluating conditions within the group are presented in Table 1.

Multi-group CFA, and Rasch analysis, were performed to test DIF between the five countries. This revealed the presence of DIF for some items, but mostly of a low magnitude. Thus, the scales were not entirely invariant between countries, but to keep a sufficient number of items in the scales, no items were discarded due to DIF. Since items were discarded for other reasons, as stated above, the presence of DIF may still have been diminished. However, the possible presence of DIF between countries should be kept in mind when making cross-country comparisons.

4.1.2.3. Validity issues. The CFA reported above supported the construct validity of the seven safety climate scales. Table 2 shows the inter-correlations between the scales. Even though the scales are highly related to each other, suggesting the possibility of a second order safety climate factor, all but one of the scales had a unique component. The exception was *workers' safety commitment*, which was highly correlated with *safety communication, learning and trust*.

An important validity issue for a climate scale is its capacity to capture the shared perceptions among workers in organizational units. Based on one-way ANOVA, with construction site as the independent variable (34 sites), ICC was calculated for the seven safety climate scales, see Table 2. All scales showed significant F values ($p < 0.05$), and thus distinguished between construction sites. ICC(1) was 0.08–0.19, and ICC(2) was 0.57–0.79. In addition, ICC(1) for the safety climate scales were several times higher than that for the variable *safety motivation*, which is an individual level construct.

As an indication of the criterion validity with regard to *safety motivation* and *safety violations*, the bivariate correlations between the seven safety climate variables and the two criterion variables were calculated (Table 2). All variables were also aggregated to the site level and the correlations were calculated in level two data as well. The correlations with *safety motivation* were all significant ($p < 0.05$) and in the range 0.41–0.58 at the individual level, and in the range 0.50–0.75 at the site level. The correlations with *safety violations* at the individual level were in the range −0.18 to −0.40 and all significant, and at the site level the correlations ranged from −0.25 to −0.66, and all but one were significant ($p < 0.05$), see Table 2.

Table 1
Development of the Nordic Safety Climate Questionnaire — study 1: Content and reliability of the seven safety climate scales. Results are given for the total sample, as well as for each Nordic subsample: Denmark, Finland, Iceland, Norway and Sweden.

Scale	Number of items	Internal consistency (Cronbach's alpha)	Internal consistency in each subsample (alpha)				
			DK	FI	IC	NO	SE
1. Management safety priority, commitment and competence	9	0.87	0.84	0.89	0.89	0.85	0.88
2. Management safety empowerment	4	0.73	0.74	0.79	0.81	0.63	0.67
3. Management safety justice	4	0.71	0.60	0.79	0.74	0.68	0.72
4. Workers' safety commitment	6	0.77	0.80	0.84	0.79	0.71	0.73
5. Workers' safety priority and risk non-acceptance	7	0.80	0.77	0.81	0.81	0.82	0.77
6. Safety communication, learning, and trust in co-worker safety competence	8	0.79	0.76	0.75	0.85	0.80	0.76
7. Workers' trust in the efficacy of safety systems	7	0.82	0.80	0.85	0.81	0.79	0.83

Table 2
Development of the Nordic Safety Climate Questionnaire – study 1: descriptive statistics and inter-correlations between the seven safety climate scales (5-step response format), *safety motivation* and *safety violations*, based on individual level data, and data aggregated to the work site level, respectively. Entire sample within the construction industry.

Variable	1	2	3	4	5	6	7	8	9	ICC1	ICC2
1. Management safety priority, commitment and competence		0.87	0.88	0.64	0.72	0.63	0.48	0.65	−0.61	0.19	0.79
2. Management safety empowerment	0.65		0.83	0.53	0.62	0.66	0.38	0.69	−0.65	0.11	0.67
3. Management safety justice	0.65	0.59		0.66	0.70	0.65	0.40	0.75	−0.53	0.10	0.63
4. Workers' safety commitment	0.56	0.46	0.46		0.57	0.69	0.62	0.64	−0.25#	0.09	0.60
5. Workers' safety priority and risk non-acceptance	0.54	0.43	0.45	0.56		0.66	0.57	0.60	−0.66	0.08	0.58
6. Safety communication, learning, and trust in co-worker safety competence	0.58	0.54	0.51	0.70	0.49		0.71	0.62	−0.54	0.08	0.57
7. Workers' trust in the efficacy of safety systems	0.47	0.44	0.40	0.62	0.46	0.63		0.50	−0.36	0.10	0.65
8. Safety motivation	0.50	0.41	0.48	0.46	0.58	0.48	0.51		−0.46	0.04	0.37
9. Safety violations	−0.31	−0.22	−0.26	−0.18	−0.40	−0.23	−0.19	−0.37		0.05	0.46
Mean	3.62	3.57	3.70	3.67	3.23	3.79	3.88	3.79	1.51		
SD	0.63	0.63	0.61	0.55	0.65	0.45	0.52	0.51	0.52		

Lower triangle: individual level correlations ($n = 660$), all significant at $p < 0.001$. Upper triangle: work site level correlations for 34 sites, where all correlations except the one marked # were significant ($p < 0.05$). Weighted k rater per target = 15.9. Safety climate scales: scale range 1–5. *Safety motivation*: scale range 1–5. *Safety violations*: scale range 1–3.

4.1.2.4. Conclusions. The final seven safety climate scales, with 45 items, showed reasonably good reliability and validity. The initially hypothesized seven dimensions were reorganized, resulting in seven new dimensions. However, these dimensions followed the hypothesized facets, or were mergers of á priori hypothesized dimensions. Furthermore, there was no need to move any items outside the hypothesized structure, i.e. to another dimension. Thus, the theoretically proposed structure received strong support.

Several observations were excluded during the initial data screening, and it is therefore relevant to question whether the results apply to the total, unrestricted sample. In order to test this, the models were fitted to the total sample, including the discarded observations, by means of CFA. It was found that the model fit was then worse than that reported above, but by introducing a nested instrument latent variable, representing the specific variation in the reversed items, the fit improved dramatically. By modeling the instrument artifact introduced through the reversed items, it could thus be shown that the final model received support – also in the total sample.

The Rasch analysis, carried out during the test of DIF, showed the presence of reversed thresholds in some items. This indicated a possible problem with the middle response alternative, labeled "*Neither agree nor disagree*". This problem was approached later (see study 3).

In order to test the validity of NOSACQ in another context than construction, a second study was performed.

4.2. Study 2

4.2.1. Method and material, study 2

The second study tested the revised NOSACQ prototype in a sample of Swedish food industry workers ($n = 288$). The workers were all blue collar workers, 83% were male, and the mean age was 39.4 years ($SD = 13.1$). Based on study 1, the questionnaire consisted of seven dimensions, measured by 45 items. To strengthen the dimensions, three new items were added to *management safety empowerment*, and two items were added to *management safety justice*. A five-step response format was used in this study. For validation purposes, two measures were included. The first criterion measure was *safety motivation*, (13 items, alpha = 0.88 in the present study), which was the same scale as the one used in study 1. The second criterion measure was self-rated safety behavior (Pousette et al., 2008), a proximal criterion of safety performance (6 items, alpha = 0.89 in the present study). CFA was performed using AMOS 7, and Cronbach's alpha and bivariate correlations were calculated using SPSS 15.

4.2.2. Results study 2

The results of study 2 showed that the factor structure could be fairly well replicated for the three safety management scales (Chi-square = 591.2, df = 206, $p < 0.001$, CFI = 0.88, RMSEA = 0.081) as well as for the four safety climate scale evaluation conditions within the group (Chi-square = 856.3, df = 344, $p < 0.001$, CFI = 0.88, RMSEA = 0.072). However, the scales *workers' safety commitment* and *safety communication, learning, and trust in co-worker safety competence* were highly related to each other. Standardized factor loadings ranged from 0.46 to 0.82 and were all highly significant. The new indicators for *management safety empowerment* and for *management safety justice* showed high factor loadings. Reliability was calculated and found good for all scales: *management safety priority, commitment and competence*: 9 items, alpha = 0.88; *management safety empowerment*: 7 items, alpha = 0.88; *management safety justice*: 6 items, alpha = 0.81; *workers' safety commitment*: 6 items, alpha = 0.85; *workers' safety priority and risk non-acceptance*: 7 items, alpha = 0.86; *safety communication, learning, and trust in co-worker safety competence*: 8 items, alpha = 0.87; *workers' trust in the efficacy of safety systems*: 7 items, alpha = 0.87. Table 3 shows inter-correlation between the safety climate scales, and their correlations with criterion variables. All safety climate scales were significantly associated with *safety motivation* and self-rated *safety behavior.*

As stated above, the Rasch analysis carried out in Study 1 in the test of DIF, showed the presence of reversed thresholds in some items, which indicated a possible problem with the middle response alternative, labeled "Neither agree nor disagree". A third study was therefore conducted to address the response format.

4.3. Study 3

4.3.1. Methods and material, study 3

Since the Rasch analysis had shown reversed thresholds involving the middle response alternative (labeled 'Neither agree nor disagree') in some items, response format was elaborated. In this third study the questionnaires were divided into two equal lots. In one lot the original five-step response format was maintained, and in the other a four-step response format was used (omitting the

Table 3
Development of the Nordic Safety Climate Questionnaire – study 2: descriptive statistics and inter-correlation between the seven safety climate scales (5-step response format), *safety motivation*, and *safety behavior*. Sample: Swedish food industry, $n = 288$.

Variable	1	2	3	4	5	6	7	8	9
1. Management safety priority, commitment and competence									
2. Management safety empowerment	0.80								
3. Management safety justice	0.71	0.74							
4. Workers' safety commitment	0.67	0.65	0.64						
5. Workers' safety priority and risk non-acceptance	0.64	0.56	0.53	0.62					
6. Safety communication, learning, and trust in co-worker safety competence	0.70	0.74	0.72	0.81	0.59				
7. Workers' trust in the efficacy of safety systems	0.50	0.54	0.61	0.68	0.56	0.68			
8. Safety motivation	0.50	0.49	0.50	0.59	0.69	0.56	0.63		
9. Safety behavior	0.41	0.35	0.36	0.43	0.63	0.43	0.45	0.71	
Mean	3.49	3.49	3.91	3.87	3.48	3.84	4.11	4.03	5.35
SD	0.83	0.83	0.74	0.82	0.89	0.74	0.72	0.67	1.08

All correlations are significant at $p < 0.001$. Safety climate scales: scale range 1–5. *Safety motivation*: scale range 1–5. *Safety behavior*: scale range 1–7.

middle response alternative). The study was based on a convenience sample of 139 construction workers from nine different work sites; one in Denmark ($n = 16$), and eight in Finland ($n = 3$, 5, 7, 10, 11, 22, 28 and 37). Most of the respondents (96%) were male, and 17% of the respondents were leaders. Average age was 41.6 years (SD = 12.1). Rasch analysis was performed (using RUMM2020) for each scale in each response format.

4.3.2. Results study 3

Results from the 14 Rasch models are shown in Table 4. They showed good model fit (non-significant Chi-square) for all scales using the four-step response format, as well as for the scales using the five-step response format. Item residual means were within +/− 0.4 for four of seven scales using the four-step response format, and five of seven scales using the five-step format. Item residual standard deviations were lower than 1.4 for all seven scales using the four-step response format, and five of seven scales using the five-step format. Three of seven analyses using the four-step format showed one item each having reversed thresholds. All seven analyses using the five-step format showed one or more items having reversed thresholds, in all 22 items. Separation index, a reliability index comparable to Cronbach's alpha, was on average similar for the response formats, 0.81 for the four-step response format and 0.83 for the five-step format.

Since reversed thresholds were more frequent for the five-step format, and the reliability was of the same magnitude for both formats, this strongly supported the use of the four-step response format.

4.4. Study 4

4.4.1. Method and material, study 4

In order to test the safety climate scales with the four-step response format in a larger and diversified sample, a fourth study was conducted based on a convenience sample ($n = 160$) from four Nordic countries The Swedish subsample ($n = 80$) comprised blue collar construction workers and supervisors. The Danish subsample ($n = 36$) comprised blue collar construction workers. Iceland contributed two sub-samples, one from nursing ($n = 17$) and one composed of occupational safety and health inspectors ($n = 15$). The Norwegian subsample ($n = 12$) were airport staff comprising senior managers and team leaders ($n = 4$) and blue collar workers ($n = 8$). A majority, 81%, of the respondents were male, and 31% of the respondents were leaders. Average age was 44.3 years (SD = 13.7). The four-step response format was used in all questionnaires, and positive and negative sense items were randomized within each dimension. CFA was performed using AMOS 7, and Cronbach's alpha and bivariate correlations were calculated using SPSS 15.

The criterion validity with regard to safety standard was tested by calculation of the bivariate correlations between the seven safety climate scales and two outcome variables: *safety grade*, a single-item variable validated in health care and the petroleum sector (Olsen, 2008a), and *overall perceptions of safety*, captured by four items and validated in a hospital setting (Cronbach's alpha: 0.76), (Olsen, 2008b).

4.4.2. Results study 4

Factor structure was confirmed for the three safety management scales (Chi-square = 399.3, df = 206, $p < 0.001$, CFI = 0.86, RMSEA = 0.077), as well as for the four safety climate scales evaluating conditions within the group (Chi-square = 603.4, df = 344, $p < 0.001$, CFI = 0.86, RMSEA = 0.069). All factor loadings were significant. Reliability, calculated as Cronbach's alpha, was good for all seven scales: *management safety priority, commitment and competence*: 9 items, alpha = 0.85; *management safety justice*: 6 items, alpha = 0.79; *management safety empowerment*: 7 items, alpha = 0.81; *workers' safety commitment*: 6 items, alpha = 0.86; *workers' safety priority and risk non-acceptance*: 7 items, alpha = 0.81; *safety communication, learning, and trust in co-worker safety competence*: 8 items, alpha = 0.85; *workers' trust in the efficacy of safety systems*: 7 items, alpha = 0.85. Table 5 shows inter-correlations between the dimensions.

The bivariate correlations between the seven safety climate scales, and the two outcome variables were all significant, and in the range 0.46–0.61 for *safety grade*, and 0.36–0.62 for *overall perceptions of safety* (Table 5).

4.5. The final questionnaire

NOSACQ-50 contains seven safety climate dimensions, comprising 50 items with 22 items evaluating management policies, procedures and practices, and 28 items evaluating workgroup ditto. The NOSACQ-50 safety climate dimensions and examples of items are presented in Table 6. NOSACQ-50 is available in English and in five Nordic languages (Danish, Finnish, Icelandic, Norwegian, and Swedish). Through the cooperation with researchers in other countries it has also been, or is presently being, translated and tested in several other languages, e.g. Chinese, Czech, Dutch, French, German, Hungarian, Indonesian, Italian, Japanese, Persian, Polish, Portuguese, Russian, Slovene, Spanish and Turkish.

5. Discussion

The main purpose of the present studies was to develop a Nordic questionnaire for measuring safety climate (NOSACQ). The theoretical foundation of NOSACQ-50 is described, and throughout the

Table 4
Development of the Nordic Safety Climate Questionnaire – study 3: Rasch results for two response formats. Item fit residuals, item-trait interaction, separation index, and number of reversed thresholds.

Dimension	No. items	4-step response format							5-step response format						
		Item residual mean	Item residual SD	Total Chi^2	Df	*p*	Sep. index	No. reversed thresholds	Item residual mean	Item residual SD	Total Chi^2	df	*p*	Sep. index	No. reversed thresholds
Management safety climate															
1. Management safety priority, commitment and competence	9	−0.17	0.73	7.6	18	0.98	0.82	0	−0.21	1.33	22.3	18	0.22	0.86	4
2. Management safety empowerment	7	−0.33	0.51	19.8	14	0.14	0.76	0	0.27	0.88	13.9	14	0.45	0.78	2
3. Management safety justice	6	−0.56	0.54	3.4	12	0.99	0.79	0	0.02	0.47	11.3	12	0.50	0.74	4
Workgroup safety climate															
4. Workers' safety commitment	6	−0.32	0.92	17.3	12	0.14	0.77	0	−0.14	1.62	8.1	12	0.77	0.87	3
5. Workers' safety priority and risk non-acceptance	7	−0.32	0.74	11.5	14	0.64	0.83	1	0.06	1.92	23.2	14	0.06	0.87	3
6. Safety communication, learning, and trust in co-worker safety competence	8	−0.57	0.63	14.2	16	0.58	0.82	1	−0.43	1.31	11.3	16	0.79	0.85	2
7. Workers' trust in the efficacy of safety systems	7	−0.84	1.13	10.0	14	0.76	0.87	1	−0.53	1.14	17.8	14	0.22	0.82	4

development process validity and reliability concerns have been highly emphasized. Both these issues are important. Confusion within scientific areas often relates to a lack of evidence concerning reliability and validity. Psychometric safety climate instruments are being used on a large scale to investigate safety in organizations. It is therefore important to obtain information about the psychometric properties of safety climate instruments. Still, as stated by Flin et al. (2006), few safety climate questionnaires have evidenced validity, and attempts to replicate factor structure when using the same instrument in different contexts have largely failed (e.g. Brown and Holmes, 1986; Dedobbeleer and Béland, 1991; Coyle et al., 1995). This has had obvious consequences for the possibility to perform comparative studies. Glendon (2008b) found, in a review of 203 refereed articles with a prime focus on safety climate or culture, published in the period 1980–2008, that less than 2% of the studies were cross-national. To ensure that survey instruments are valid and reliable, instruments developed in one context should be validated before use in a new context (Pronovost and Sexton, 2005). The present work aimed at developing measures of safety climate that were replicable across nations, and the properties of NOSACQ were explored, with satisfactory validity and reliability in five different countries, using native languages. Particularly important were the results supporting criterion validity in site level aggregated data in study 1, where all safety climate dimensions were found to be associated with workers' *safety motivation*, and all but one with fewer *safety violations*. These associations are less likely to be influences by common method variance (CMV), which can inflate associations at the individual level.

Another important result, with regard to validity, was the satisfactory high intra-class correlations (ICC) found in study 1. This implies that the safety climate scales have the capacity to sufficiently capture the shared perceptions among workers in organizational units. We think the rigor in operationalization of concepts and wording of items probably contributed to this. The validity of NOSACQ was further confirmed by its ability to distinguish between organizational units through detecting significant differences in safety climate.

NOSACQ was also successfully tested in two different occupational contexts. The results support the existence of certain generic, theoretically grounded features of safety climate. This also opens up the possibility of coordination of research using the same instruments in comparative studies, potentially increasing the understanding of cross-contextual differences and similarities with regard to safety climate. The results, however, also point at the challenges of maintaining the meaning of items when translating a questionnaire into a different language. The procedure of translation and back-translation is therefore important, and differential item functioning (DIF) analysis proved to be an important tool to identify problematic items. In comparative studies any remaining DIFs can be dealt with through Rasch analysis.

A design criterion applied in the development of NOSACQ-50 was to use a mix of items assessing the phenomena directly or reversed. The purpose of including reversed items was to minimize stereotype response patterns. The idea is that the reversed items would act as “cognitive speed bumps” (Podsakoff et al., 2003, p 884), i.e. that they would make the respondent slow down and read the text thoroughly. However, it was found that this procedure also introduced an unwanted side effect, i.e. an instrument factor connected to the reversed items. Some respondents obviously did not “slow down”, and did not pay attention to the reversed items. This was revealed by the explorative factor analysis, where reversed and non-reversed items loaded in different components. This also affected the model fit in the confirmatory factor analysis (CFA). This fit was on the limit to be acceptable in several instances. By

Table 5
Development of the Nordic Safety Climate Questionnaire – study 4: descriptive statistics and inter-correlation between the seven safety climate scales (4-step response format), *safety grade* and *overall perception of safety*. Sample: construction, nursing, safety and health inspectors, airport staff, $n = 160$.

Variable	1	2	3	4	5	6	7	8	9
1. Management safety priority, commitment and competence									
2. Management safety empowerment	0.72								
3. Management safety justice	0.70	0.70							
4. Workers' safety commitment	0.54	0.50	0.45						
5. Workers' safety priority and risk non-acceptance	0.59	0.49	0.44	0.58					
6. Safety communication, learning, and trust in co-worker safety competence	0.63	0.66	0.64	0.68	0.59				
7. Workers' trust in the efficacy of safety systems	0.48	0.46	0.47	0.53	0.46	0.66			
8. Safety grade	0.61	0.46	0.53	0.58	0.53	0.58	0.47		
9. Overall perception of safety	0.62	0.52	0.53	0.62	0.59	0.59	0.36	0.65	
Mean	2.96	2.96	3.25	3.17	2.93	3.16	3.43	3.36	2.84
SD	0.52	0.50	0.50	0.56	0.60	0.47	0.48	0.80	0.59

All correlations are significant at $p < 0.001$. Safety climate scales: scale range 1–4. *Safety grade*: scale range 1–5. *Overall perception of safety*: scale range 1–4.

modeling the instrument factor, it was shown that the common variation in the reversed items was the main source of misfit. In conclusion, we maintain that it is advisable to use the procedure with reversed items. Without the reversed items, the model fit could have been better, but a stereotype response pattern would probably have passed unnoticed. With the reversed items, at least such low quality responses can be identified and dealt with properly.

Initially it was decided to use a five-step Likert type, response format. Study 3 showed that this was not an ideal decision. It was shown that omission of the middle response alternative reduced the problem with reversed thresholds substantially. It is an important quality of a response scale that the response alternatives are ordered. The middle response alternative seemed to introduce more confusion than information, and our interpretation was that some respondents used "Neither agree nor disagree" as "I don't know". So, it was decided to use a four-step response format in the final version of NOSACQ-50. A possible negative effect of using an even numbered format is that some respondents may be forced to make a positive or negative choice, although this does not mirror their actual opinion.

Table 6
The Nordic Safety Climate Questionnaire (NOSACQ-50): Safety climate dimensions, facets and exemplifying items.

Dimension	Facets	Example item
1) Management safety priority, commitment and competence (9 items)	Workers' perceptions of management • prioritizing safety • being active in promoting safety and reacting to unsafe behavior • showing competence in handling safety • communicating safety issues	Management accepts workers taking risks when the work schedule is tight[a] We who work here have confidence in the management's ability to deal with safety
2) Management safety empowerment (7 items)	Workers' perceptions of management empowering workers and supporting participation	Management encourages workers to participate in decisions which affect their safety
3) Management safety justice (6 items)	Workers' perceptions of management treating workers who are involved in accidents fairly	Management looks for causes, not guilty persons, when an accident occurs
4) Workers' safety commitment (6 items)	Workers' perceptions of how they themselves relate to safety at work concerning if they generally: • show commitment to safety and are active in promoting safety • care for each others' safety	We who work here take no responsibility for each others' safety[a]
5) Workers' safety priority and risk non-acceptance (7 items)	Workers' perceptions of how they themselves relate to safety at work concerning if they generally: • prioritize safety before production goals • do not resign to hazardous conditions or accept risk-taking • do not show fearlessness	We who work here accept dangerous behavior as long as there are no accidents[a]
6) Safety communication, learning, and trust in co-worker safety competence (8 items)	Workers' perceptions of how they themselves relate to safety at work concerning if they generally: • discuss safety whenever such issues emerge and learn from experience • help each other to work safely • treat safety suggestions from each other seriously and try to work out solutions • trust each others' ability to ensure safety in everyday work	We who work here can talk freely and openly about safety
7) Workers' trust in the efficacy of safety systems (7 items)	Workers' perceptions of how they themselves relate to safety at work concerning if they in general: • consider formal safety systems as effective, e.g. safety officers, safety representatives, safety committees, safety rounds • see benefit in early planning • see benefit in safety training • see benefit in clear safety goals and objectives	We who work here consider that safety rounds have no effect on safety[a]

[a] Reverse scored items.

In accordance with the definition of safety climate as a shared phenomenon, the NOSACQ-50 items were phrased so that the individual respondent is encouraged to report on perceptions shared within the workgroup, i.e. a referent-shift approach (Glisson and James, 2002). This is often overlooked in the development of safety climate instruments. The present results of significantly higher ICC regarding the safety climate dimensions than regarding *safety motivation*, support the ability of NOSACQ-50 to capture the shared phenomenon safety climate.

This study has some important limitations that should be kept in mind, and also points to areas for future research. The gender distribution in all four development studies was skewed, with women being underrepresented. In addition, the studies reported in this paper were conducted in a limited number of industries with rather small samples. This raises the issue of generalizability to a wider workforce context. The development of NOSACQ started with the construction industry in mind. In the first study, the factor structure showed to be robust in the construction industry in all five Nordic countries. In the second study, NOSACQ was cross-validated in an industry with very different properties: the food industry. While the construction industry is characterized by temporary work organizations and changing work tasks during projects phases, the food industry is characterized by a more stable work organization, and highly standardized work. The factor structure was replicated in this new work context, as well as in the fourth study, with a diversified sample. Therefore, we believe that the conceptual structure is stable, and may be generalized to other industries where workers are exposed to risk of injury. However, it is important to further test this hypothesis in samples with other gender distributions, and in a wider range of industries. It is also well known that translations of questionnaire instruments to new languages may induce DIF, due to different understandings of phenomena in different cultural contexts. Therefore, psychometric properties should be evaluated whenever NOSACQ-50 is translated into a new language version.

The sample size in the three studies testing the factor structure (study 1, 2 and 4) was in the range 160–660 observations. This satisfies the recommendations by Loehlin (1992), of 100–200 cases for CFA with two to four factors. Regarding study 1, the recommendations by Bentler and Chou (1987), of five cases per estimated parameter, were also fulfilled in the full CFA model, while they were not fulfilled in the more complex multi-group CFA. In study 2 and study 4, the number of cases was somewhat low in relation to the number of estimated parameters. An issue related to that of the sample size is the requirement, in climate research, that the data should be collected from different work units (Shannon and Norman, 2009), and thus could be expected to have a variation at the group level. We strived for fulfillment of this requirement in all studies reported here.

Another issue of concern is the possibility that CMV may have affected the results due to the cross-sectional design, where all the data were collected by self-report. In fact, a method factor was identified in the factor analysis in study 1, but including this method factor in the CFA model as a nested factor made the model fit better, and further validated the conceptual structure of the instrument. Thus we conclude that CMV is not a threat to the conclusions regarding dimensionality. Concerning the criterion validity, tested as correlations between the safety climate dimensions and self-reported outcomes, we acknowledge that the associations are likely to be inflated by CMV. However, when the observations were aggregated to the group level, which is less susceptible to be inflated by CMV, the pattern of associations was consistent. Still it would be desirable with future studies validating the scales against external criteria variables, emanating from another source than the individuals assessing the safety climate.

Rather than being a global measure of safety climate, NOSACQ-50 offers a multi-level, multi-facetted and thus more in-depth perspective. It enables evaluation of seven different dimensions that, in previous research, have shown to be of importance to safety. Although the dimensions are highly related to each other, each one contributes some uniqueness. This allows a more specific identification of areas for improvement in an organization, once an adequate reference database has been established. Such a reference database has been initiated by the present authors through the cooperation with several international research teams testing and using NOSACQ-50 in different contexts. NOSACQ-50 results can thus be used in cross-sectional studies for benchmarking within and between countries, multi-national organizations, companies, departments and groups, as well as in longitudinal studies such as in evaluating the effects of safety climate interventions.

Acknowledgments

The development of NOSACQ-50 was partially financed by the Nordic Council of Ministers (project number 411050-30163), which is hereby gratefully acknowledged. We would also like to acknowledge the contribution of physician Hans Magne Gravseth, National Surveillance System for Work Environment and Occupational Health, Norway, who participated in the initial stages of the questionnaire development.

Appendix. Supplementary material

Supplementary data associated with this article can be found in the on-line version, at doi:10.1016/j.ergon.2011.08.004.

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