Safety climate and safety culture in health care and the petroleum industry: Psychometric quality, longitudinal change, and structural models

by
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Preface

In many ways, this journey started when I was hired as a research scientist at Rogaland Research in 2002. I relatively quickly realized the important role that safety research played in the Stavanger region, centred on a relatively large petroleum industry. During the last five years of research, patient safety has also evolved quickly in the region, possibly benefiting from safety research within the petroleum industry.

I need to thank many persons for their contributions during the process of completing this Ph.D. First of all I would like to thank my supervisors Torbjørn Rundmo, Karina Aase, and Knud Knudsen for their encouragement during the process. Torbjørn was encouraging from the beginning when I asked him to be my supervisor and has been very inspirational to work with. Meanwhile, Karina—in many ways—got me started studying safety in healthcare. I am deeply grateful for all the help and support she has contributed with. Finally, Knud has been the enthusiastic person with whom to discuss methodological issues. I am indebted to my supervisors for their support.

The relatively large data material investigated in this Ph.D. has been possible thanks to the cooperation with various institutions, projects, and persons. A phone call from Jorunn Tharaldsen initiated my work in the Ph.D. process when she suggested writing a paper based on survey data as part of the Risk Level on the Norwegian Continental Shelf project.

The safety programme study was initiated thanks to Tor Tønnessen. This study was formally organised as a research project at Rogaland Research (later renamed to International Research Institute of Stavanger). The project received more added value when cooperation started with Tor Olav Nævestad, Knud Haukelid, and Anne Mette Bjerkan at University of Oslo. I also appreciate the help from Odd Fallmyr and Jan-Henry Larsen during the implementation of the safety culture programme study.

Karina Aase was responsible for the patient safety project organised at University of Stavanger. This project made it possible to collect longitudinal survey data in a large regional hospital. Other helpful persons during the patient safety study included Stein Tore Nilsen, Arild Johansen, Liss Søreide, and Geir Øyvind Bakka. It has been inspirational to discuss safety issues with all the project members of the patient safety group at UiS, especially Sindre Høyland, Siri Wiig, and Randi Thommasen.

I also would like to thank the Nordic safety climate network that I have been attending for some years now, especially Pete Kines, Jorma Lappalainen, Kim Lyngby Mikkelsen, Anders Pousette, and Marianne Törner.

Furthermore, I appreciate that Karlene H. Roberts agreed to be my formal contact at Berkeley, making a research stay there possible. I would particularly like to thank Karlene and Emery Roe at Berkeley for their reflections on my work.

I would also like to thank all my colleagues at the Risk Management and Societal Safety group at University of Stavanger. My Ph.D. period was founded by the University Foundation of Rogaland.

Finally, I want to thank my family for their encouragement. I dedicate this thesis to Maria and our two wonderful children, Daniel and Mikal.

Stavanger, July 2009

Espen Olsen

Summary

This thesis presents four empirical studies of safety climate and one study of a safety culture programme. Four aims were defined to guide the conducted work: 1) assess safety climate in health care and petroleum and evaluate the psychometric properties of instruments used; 2) study the stability versus changeability of safety climate over time; 3) investigate the possibility of identifying a common safety climate structural model in health care and petroleum; and 4) improve knowledge about the dynamics and effects of safety culture programmes through development and testing of a structural model.

Longitudinal designs were used to assess safety climate in both specialised health care and among workers on offshore platforms over a two-year period. In addition, cross-sectional data were explored to investigate the possibility of a common safety climate model in specialised health care and petroleum. A mixed method design was used to develop and validate a structural model that could illustrate the dynamics of a safety culture programme implemented in a large petroleum company.

Hospital Survey on Patient Safety Culture (HSOPSC), developed by Sorra and Nieva (2004), was translated into Norwegian and used to assess safety climate at a large regional hospital in two measurement waves. A new instrument—Norwegian Offshore Risk and Safety Climate Inventory (NORSCI)—was similarly used to assess safety climate on the Norwegian continental shelf during two measurement waves. Two-year intervals were used between measures.

The psychometric properties of the Norwegian version of HSOPSC and NORSCI were considered valid and satisfactory for both measurements. Results from the hospital suggest that the safety climate level was relatively stable during the measurement period, indicating that implemented improvement efforts have had relatively little impact on safety climate dimensions. Three safety climate dimensions were improved, two were reduced, and five had no significant change. On the continental shelf, four safety climate scores improved during the period, while one dimension was lowered.

After adaptations, development, and validations of comparable safety climate concepts based on HSOPSC, factor analysis revealed six identical cross-industrial measurement concepts that could be used to develop a common structural model in health care and petroleum: 1) learning, feedback, and improvement; 2) teamwork within units; 3) supervisor/manager expectations and actions promoting safety; 4) transitions and teamwork across units; 5) organisational management support for safety; and 6) stop working in dangerous situations. A structural model assessment supported the hypothesised structural links specified among these dimensions—namely, safety climate variables at higher organisational levels influenced safety behaviour via safety climate dimensions at lower organisational levels. However, this model could only be generalised to fit health care and offshore petroleum workers, not onshore petroleum workers.

To explore the dynamics of a safety culture programme, a mixed method approach was adopted using qualitative interviews, fieldwork, and a questionnaire survey. Five measurement concepts were validated and incorporated into a hypothetical structural model: 1) participation in a two-day kickoff; 2) effectiveness of programme implementation; 3) personal programme commitment; 4) safety behaviour change; and 5) safety culture change. The final model developed illustrates in particular how the levels of personal programme commitment and effectiveness of programme implementation influence the level of change regarding safety behaviour and safety culture. Another finding was that participation in the two-day kickoff had both positive and negative influences due to the high expectations developed among workers. Safety behaviour change influenced safety culture change and vice versa, which was also hypothesised.

List of papers

This thesis is based on the following papers:

PAPER 1

Olsen, E. (2008). Reliability and Validity of the Hospital Survey on Patient Safety Culture at a Norwegian Hospital. In J. Øvretveit and P. J. Sousa (Eds.), *Quality and Safety Improvement Research: Methods and Research Practice from the International Quality Improvement Research Network (QIRN)* (pp. 173-186). Lisbon: National School of Public Health[1].

PAPER 2

Olsen, E., & Aase, K. (2009). Validity and reliability of the Hospital Survey on Patient Safety Culture and exploration of longitudinal change at a hospital. *Safety Science Monitor*, submitted.

PAPER 3

Tharaldsen, J. E., Olsen, E., & Rundmo, T. (2007). A longitudinal study of the safety climate on the Norwegian continental shelf. *Safety Science, 46*, 427-439.

PAPER 4

Olsen, E. (2009). Exploring the possibility of a common structural model measuring associations between safety climate factors and safety behaviour in health care and the petroleum sectors. *Accident Analysis and Prevention*, resubmitted.

PAPER 5

Olsen, E., Bjerkan, A. M., & Nævestad, T. O. (2009). Modelling the effects of a large-scale safety culture programme: A combined qualitative and quantitative approach. *Journal of Risk Research*, *12*, 1-21.

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Contents

Part I

1 Background and problem

This research was conducted in light of safety challenges in different work settings, and particularly health care and petroleum settings. Organisational safety-related factors—namely, factors relating to the theoretical field of safety culture and safety climate—are the building blocks of the present thesis. The importance and relevance for studying such issues are the assumed significance these factors have for the safety performance of organisations. What may be considered relevant safety performances to achieve depends on the setting on which we are focusing. Generally organisations should aim at preventing death, injury and occupational illness, and additionally, protect the resources and environments within the settings they operate (Maguire, 2006). An assumption is that research on safety climate and safety culture in the long run may gain knowledge that will potentially improve the safety performance of organisations and, ultimately, the safety of societies.

Studies in the thesis have been conducted in specialised health care and petroleum sectors. The Norwegian work life is the contextual setting for the conducted studies. Health care and petroleum sectors are currently facing several safety challenges, which is the main reason why the studies have been conducted in these sectors. Both sectors have a significant potential for injuries and adverse events. The offshore petroleum industry is considered hazardous due to such hazards as fire, explosion, and blow-outs as well as the risk of minor work injuries that may harm workers (Kringen, 2009). In health care, safety and risk issues may be related to different phases of patient care and diagnostic, treatment, preventive, or other system failures (Institute of Medicine, 2000). In the Norwegian health care setting, adverse events are believed to cause approximately 2000 to 3000 patient deaths annually; a large share of these deaths is considered to be preventable (Hjort, 2004). Injuries to health care workers come in addition (DeJoy, Murphy & Gershon, 1995).

Four of the studies in this thesis concentrate on empirical investigations of safety climate. Generally speaking, safety climate is measured by the use of workforce questionnaire surveys; such assessments can be regarded as the surface features of the underlying safety culture (Flin et al., 2000). Several safety climate instruments have been developed, but the scientific value of them depend on the psychometric quality (Flin et al., 2006) and replicability of measures (Netemeyer, Bearden & Sharma, 2003). Validity concerns are also fundamental for safety research to move forward in forms of developing, confirming, adjusting, comparing, and modelling of theoretical and measurement concepts. Thus, aspects with regard to validity and reliability are significant issues being addressed in the thesis; aspects that are important and necessary to address before other issues relating to longitudinal trends and structural models can be investigated.

Safety climate generally has the potential to vary within (Zohar, 2003) as well as between organisations (Singer et al., 2003) and sectors (Gaba et al., 2003). Safety climate features used in health care are most often adapted from other industries. This research trend indicates that cross-industrial overlaps exist with regard to safety-related concepts and challenges. Previous research has suggested that the safety climate level is less "ideal" in hospitals compared to the aviation sector (Gaba et al., 2003; Sexton, Thomas & Helmreich, 2000), but there is a lack of studies developing and assessing safety climate models across sectors. Such research will potentially have a high impact on the understanding of mechanisms related to safety climate.

It is an open research question if it is possible to identify common safety climate factors across health care and petroleum. If the answer is yes, another question emerges: Is it possible to develop a common explanatory model involving the common measurement concepts, and will these models be supported and replicated in survey samples across sectors? The possibility of a common safety climate model across health care and other sectors has been suggested by Flin (2007), but surprisingly little research has been conducted to support this idea. These issues are part of the reason why health care and petroleum are depicted research settings for this thesis. Combining studies in two sectors may also create potential benefits in the understanding of safety and prevention of accidents across sectors.

Exploring the stability versus changeability of safety climate factors in both sectors is a central issue in this thesis. Safety climate was therefore monitored over a two-year measurement period in both health care and petroleum. Researchers (e.g. Moran & Wolkwein, 1992) have suggested that climate factors are less enduring compared to cultural aspects. The stability and improvability of safety climate and safety culture are important and fundamental issues as both concepts are linked to safety performance. The improvability of safety climate may vary across sectors; therefore, longitudinal designs have been chosen in the petroleum and health care sectors.

The last paper in the thesis addresses an empirical investigation of a safety culture programme implemented in a large petroleum company based in Norway. The purpose of the study will be twofold: to understand processes regarding the implementation, and to develop a structural model illustrating important influences of the programme. This research task is comprehensive as such programmes reflect a relatively new phenomenon in Norwegian work settings and little research has been conducted concerning their processes and effects. Thus, to achieve the goal of the study, a combined inductive and deductive approach is warranted, and a mixed method approach will be chosen to benefit from mixed methods.

Studies related to safety climate and safety culture have become widespread within the organisational safety field (Guldenmund, 2000). In the theoretical section of this thesis, these concepts will be defined and more thoroughly explained based on two related concepts; organisational culture and organisational climate. Safety culture and safety climate will in general be considered as interrelated concepts in this thesis. Safety climate surveys are one of many methods often used to assess safety culture and offer a “snapshot” of workers’ perceptions concerning organisational safety factors, including both safety politics and practises in organisational settings (Flin, 2007). Although safety culture compared to safety climate is considered a reflection of a broader and possibly more complex phenomenon, both concepts have many overlaps because they aim to understand the social systems and factors that may be of relevance for a wide area of safety and risk issues. When facing issues relating to organisational safety challenges, "conceptual wars" become less important compared to the common goal to which both concepts relate—namely, understanding the causes to, and prevention of, adverse events in organisational settings.

The general epistemology of this thesis will largely depend on psychometric theory of measurement, which is common in the assessment of safety climate. The basic idea in psychometrics is to make sense and glean knowledge about psychological and social phenomena by quantifying them. In doing so, it is possible to target problems, track organisational trends, and monitor changes due to improvement efforts in organisations[2]. Such assignments are important within the organisational safety field but depend on measurement instruments to have certain characteristics (e.g., be valid, reliable, representative, and sensitive) (Hale, 2009). The psychometric approach emphasises validity and reliability issues as well as other characteristics specified by Hale (2009), that should be attributes associated with measurement instruments of safety performance. Within the psychometric approach, questionnaires are the most common measurement procedure, and variables used are normally part of a broader theoretical framework (DeVillis, 2003). Although psychometrics is commonly used in safety climate studies, studies concerning safety culture apply a variety of other methodologies and frameworks as well (e.g., Guldenmund, 2000; IAEA, 2002; Pidgeon, 1998).

1.1 The research problem and purpose

As safety culture and safety climate are considered important antecedents of safety performance (Mearns & Flin, 1999), the overall aim of this thesis is to gain more knowledge about such factors through empirical studies in health care and petroleum. These studies will hopefully increase the understanding of safety culture and safety

[2] Within industrial and organizational psychology survey results, tracking trends and changes over time is common for investigating improvements and deterioration in key employee constructs (Rogelberg et al., 2004).

behaviour and, ultimately, this knowledge may contribute to improved understanding of antecedents of safety performance in different work settings.

Moran and Wolkwein (1992) claim that organisational climate is a "relatively enduring" characteristic of an organisation, as opposed to organisational culture, which is a "highly enduring" characteristic of an organisation. Looking deeper into this text, one could speculate what "relative enduring" and "highly enduring" actually suggest. Currently it is unclear how much time and what kind of effort is needed to improve safety culture and safety climate. To increase the understanding of these concepts, it is necessary to study the phenomenon they address over time, to understand the structural relations of different underlying dimensions, and to study what happens during improvement efforts in organisational settings. Ultimately, this will improve our understanding of safety issues and challenges in organisational contexts.

Based on this background, four specific aims have been developed to channel the direction of the work in this thesis:

1. Assess safety climate in health care and petroleum and evaluate the psychometric properties of instruments used;

2. Study the stability versus changeability of safety climate over time;

3. Investigate the possibility of identifying a common safety climate structural model in health care and petroleum; and

4. Improve knowledge about the dynamics and effects of safety culture programmes through the development and testing of a structural model.

Based on these aims, four specific research questions were developed for the conducted studies.

Will the psychometric qualities on the safety climate assessment be satisfactory? This research question is emphasised in papers 1, 2, and 3 as well as partly in paper 4. Principles supported from the psychometric research tradition (e.g., DeVillis, 2003) will guide evaluations of the psychometric properties of scales.

Will safety climate dimensions be stable or change over time? According to Moran and Wolkwein (1992), organisational climates evolve more quickly, and alter more rapidly compared to culture. The stability of safety climate is explored in papers 2 and 3, in which change will be studied based on two measurement waves conducted over two-year periods.

Is it possible to identify a common safety climate structural model in health care and petroleum? The possibility of a common safety climate model in health care and other industries was suggested by Flin (2007) and will be explored in paper 4 based on a multilevel reasoning of safety climate.

Is it possible to model and assess the dynamics and effects of a safety culture programme with the use of a structural model? The question is explored in paper 5 using a mixed method design in the study of a safety culture programme implemented in a large petroleum company.

1.2 Structure of the thesis

In Part 1 of the thesis conceptual framework, theoretical perspectives, aims, and research questions will be presented, followed by an overview description of the conducted studies. This overview will include a presentation of research designs and results. Finally, an overall discussion of findings will be presented. Full versions of the conducted studies are listed in Part II of the thesis:

1. Olsen, E. (2008). Reliability and Validity of the Hospital Survey on Patient Safety Culture at a Norwegian Hospital. In J. Øvretveit and P. J. Sousa (Eds.), *Quality and Safety Improvement Research: Methods and Research Practice from the International Quality Improvement Research Network (QIRN)* (pp. 173-186). Lisbon: National School of Public Health.

2. Olsen, E., & Aase, K. (2009). Validity and reliability of the Hospital Survey on Patient Safety Culture and exploration of longitudinal change at a hospital. *Safety Science Monitor*, submitted.

3. Tharaldsen, J. E., Olsen, E., & Rundmo, T. (2007). A longitudinal study of the safety climate on the Norwegian continental shelf. *Safety Science, 46*, 427-439.

4. Olsen, E. (2009). Exploring the possibility of a common structural model measuring associations between safety climate factors and safety behaviour in health care and the petroleum sectors. *Accident Analysis and Prevention*, resubmitted.

5. Olsen, E., Bjerkan, A. M., & Nævestad, T. O. (2009). Modelling the effects of a large-scale safety culture programme: A combined qualitative and quantitative approach. *Journal of Risk Research*, *12*, 1-21.

2 Theoretical Perspectives

In this part, the most central theoretical perspectives for the background of this thesis will be presented.

2.1 Organisational culture and organisational climate

When introducing the organisational culture field, Martin, Frost and O'Neill (2006) wisely suggested that researchers should have in mind Kuhn's (1970) view of the history of science as a political struggle for the dominance of one intellectual view over another.

Cultural scholars openly argue for one point of view in preference to explicitly elaborated alternatives. Cultural research is characterised by deep disagreement about fundamental issues that have resulted in little sense of cumulative advances within the field. A review of the organisational culture should respond to the existence of the disagreements within the field (Martin et al., 2006). However, this research task goes beyond the aim and scope of this thesis[3]. In the following presentation, the theoretical field of organisational culture and organisational climate will be briefly introduced before turning to theories of safety climate and safety culture.

The concept of "organisational culture" has become a frequent term in the organisation and management literature, but the concept is contested and eludes a consensual definition. Despite this, two broad schools of thought are eminent in the literature (Burrel & Morgan, 1979; Glendon & Stanton, 2000; Langfield-Smith, 1995; Richter & Koch, 2004; Smircich, 1983). One school regards culture as something that an organisation *is*; culture then serves as a metaphor for describing an organisation and the culture is considered as neither readily

[3] For other literature on organisational culture, see, for example, Frost et al. (1991), Ashkanasy, Wilderom, and Peterson (2000), and Schneider (1990).

identifiable nor separate from the organisation itself. The other school of thought considers culture as something that an organisation *has*—namely, cultural aspects of variables in the organisation that can be isolated, described, and manipulated. If culture is something an organisation has, it may be possible to change, improve, and manage. On the other hand, if organisations simply are cultural entities, these should be understood in forms of social constructions at work, but offer less in terms of solutions to managing or shaping cultural aspects (Davies, Nutley & Mannion, 2000).

Cultural researchers disagree as to whether or not cultural elements must be shared among organisational members in order to be defined within the cultural domain. Martin (2002) has suggested both—that culture should include what is shared as well as ambiguities, paradoxes, and contradictions. To resolve this, Martin suggests a three-perspective theory of culture: integration, differentiation, and fragmentation views.

Within the integration perspective, culture is shared understandings in an organisation; consistency exists across cultural manifestations. Schein (1992) has been one of the most important contributors within this perspective. According to Schein (1992), organisational culture is defined in the following manner:

'a pattern of shared basic assumptions that the group has 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 to perceive, think, and feel in relation to those problems' (p. 12).

Schein has emphasised that organisations often fail to develop integration and rather often develop into differentiation and ambiguity (Hale, 2004). Other researchers have paid more attention to differentiation and ambiguity aspects with regard to organisational culture, which has developed into separate perspectives. The differentiation perspective emphasises cultural inconsistencies, while the fragmentation perspective focuses on ambiguity and the multiplicity of interpretations among organisational members (Martin, 2002).

Cultural researchers have also described organisational culture according to a three-level model (Glendon & Stanton, 2000). For example, Schein (1985) defined behaviours and artefacts at the most accessible level, beliefs and values at the intermediate level (espoused values), and basic assumptions at the deepest and least accessible level. Another debate is whether congruence exists between the different levels, so that (for example) information about espoused values can tell something about the basic assumptions (Moran & Volkwein, 1992).

Organisational culture theorists often try to develop guidelines on how to improve organisational performance through culture. Inspired by Lewin (1947), Schein (2004) asserts that culture change and improvement involve both unlearning and relearning, which will potentially increase workers' anxiety and resistance to change. To overcome these problems, Schein (2004) suggests organisational members must feel psychologically safe, which will potentially increase the learning potential of workers and the cultural improvements. Schein (2004) specifically emphasises the leader's role in the building, embedding, and evolvement of culture. Still, according to Johnson (1988), a number of factors can potentially influence organisational culture. Cummings and Worley (2005) have developed six guidelines on how to improve culture in organisational settings: 1) formulate a clear strategic vision, 2) display top-management commitment, 3) model cultural change at the highest level, 4) modify the organisation to support organisational change, 5) select and socialise newcomers and terminate deviants, and 6) develop ethical and legal sensitivity. These guidelines clearly relate to more general organisational change strategies (e.g., as developed by Kotter, 1996).

Although many studies were undertaken to examine organisational climate in the 1970s, a trend during the 1980s was that the term *organisational culture* replaced the term *climate* in the same type of research (Guldenmund, 2000). The interest in both concepts is significantly linked to the hypothetical explanatory power both concepts have in explaining organisational performance (Reichers & Schneider, 1990; Wilderom, Glunk & Maslowski, 2000). In addition, both concepts offer perspectives for explaining human dimensions of organisations (Smircich, 1983). Today, an ongoing debate exists concerning the differences and overlaps between the concepts.

Reichers and Schneider (1990) define organisational climate as the "shared perceptions of organisational policies, practises, and procedures, both formal and informal" (p. 22). Organisational climate has been considered a *relatively* enduring characteristic of organisations while, in contrast, organisational culture is considered a *highly* enduring characteristic. Hence, because of the history and known past, cultures evolve more slowly when compared to safety climate. However, organisational climates[4] are supposed to evolve from some of the same elements as organisational culture. Climate assessments are normally considered to grasp the social context at a shallower level. In the literature, this level is generally presumed to form more quickly and alter more rapidly when compared to deeper cultural assumptions (Moran & Volkwein, 1992).

The concepts of organisational climate and organisational culture are linked because interacting groups of individuals are informed and constrained by a common organisational culture (Moran & Volkwein, 1992). Climate is still considered more accessible than culture. It has been suggested that climate incorporates cultural elements in the two outer layers of organisational culture that Schein (1985) defined—labelled "behaviours and artefacts" and "beliefs and values" (Moran & Volkwein, 1992, p. 39). Consequently, climate can be understood as a manifestation of culture (Schein, 1985), while culture additionally exists at a higher level of abstraction (Reichers & Schneider, 1990) also including "basic assumption" in Schein's (1985) model.

Other researchers (Ashkanasy, Wilderom & Peterson, 2000; Denison, 1996; Reichers & Schneider, 1990) share many of the considerations outlined by Moran and Volkwein (1992) regarding overlaps and differences between culture and climate. Denison (1996) suggests that the two research traditions should be viewed as differences in

[4] Different forms of organisational climates have been developed, such as for example service climate (Schneider & Bowen, 1985) and safety climate (Zohar, 2003).

interpretation rather than differences in the phenomenon. According to Dennison (1996), culture and climate literature addresses a common phenomenon that refers to the creation and influence of social contexts in organisations. Reichers and Schneider (1990) identified several overlaps between climate and culture; both concepts 1) deal with the ways by which organisations make sense of their environment, 2) are learned, 3) are both monolithic and multidimensional constructs, and 4) try to identify the environment that affects behaviour of people in organisations. According to Denison (1996), the debate regarding conceptual and methodological resources is secondary to the primary goal—namely, understanding the evolution and influence of the social context in organisations.

In this section, some complex topics within the organisational culture field have been illustrated. Key points are that cultural aspects of organisations may or may not be shared among organisational members. In addition, cultural layers exist within cultures; some cultural characteristics will to some degree be observable, while cultural aspects also include unobservable aspects that may be difficult to assess and understand. Finally, improving culture may or may not be possible according to the theoretical framework used. Assuming culture as something an organisation *has,* improvement will be possible. While assuming culture as something an organisation *is*, management of culture is hard (Davies et al., 2000).

2.2 Safety culture and safety climate

The ongoing debate concerning differences in organisational culture and organisational climate is clearly also recognisable and reflected in the theoretical fields of safety culture and safety climate. This is not surprising given that the safety climate and safety culture concepts originate from the organisational culture and organisational climate concepts (Mearns & Flin, 1999).

Generally, perspectives developed to understand organisational culture can also be applied to understand the safety culture of organisations. However, compared with general studies on organisational culture, safety culture studies normally put greater emphasis on safety-related issues. The term *safety culture* was introduced following the Chernobyl accident (IAEA, 1986). Today, many safety culture definitions exist. One of the most cited definition of safety culture explain it as *"the product of individual and group values, attitudes, perceptions, competencies to, and the style and proficiency of, an organization's safety management"* (Advisory Committee for the Safety of Nuclear Installations, 1993, p. 23). In contrast, safety climate can be defined *"as the surface features of the underlying safety culture [assessing] workforce perceptions of procedures and behaviours in their work environment that indicate the priority given to safety relative to other organisational goals"* (Flin et al., 2006, p. 109). Safety climate perceptions are most typically measured by questionnaires that provide us with a "snapshot" of the current state of safety.

The literature includes a debate as to whether safety climate instruments measure safety culture or safety climate (Guldenmund, 2000). This debate is based on the common belief that questionnaires do not reveal the full depth of unconscious assumptions, but rather represent the more apparent and conscious values, attitudes, and perceptions of respondents (e.g., IAEA, 2002).

Compared to safety climate, safety culture is considered a more complex and enduring phenomenon. Safety culture includes fundamental values, norms, assumptions, and expectations whereas safety climate is assumed to be a reflection of such mechanisms, without the same depth (Mearns & Flin, 1999). Like organisational culture, safety culture studies depend primarily on qualitative methods (Guldenmund, 2000). Meanwhile, safety climate studies are typically measured by questionnaire surveys (Mearns & Flin, 1999) although such studies are often labelled as investigations of safety culture (Guldenmund, 2000).

Although confusion remains regarding the definition of safety culture, the use of the concept has increased rapidly since it was introduced. Safety managers and academics have come to believe that safety culture measurement and development will improve safety performance in a wide range of industries (Mearns & Flin, 1999). Based on a string of high profile disasters over the past two decades that have illustrated the role social and organisational issues have played in the etiologic meaning of these accidents, it is today common to believe that social structures as well as technical arrangements influence the achievement of safety-related goals (Mearns, Whitaker & Flin, 2003). Today, it has become common to view disasters as results of breakdowns in organisations' policies and procedures established to deal with safety (Pidgeon & O'Leary, 1998).

Turner (1978) was probably the first author to establish theory about the development of accidents and disasters, demonstrating they were caused by historical events including social systems of organisations. Since Turner's (1978) work, several studies have explored the relations between organisational factors and injuries. In one meta-study, Shannon et al. (1997, p. 201) found that variables' 'consistency' associated with lower injury rates were empowerment of the workforce (in general matters), delegation of safety activities, and an active role (in the health and safety work) of top management. General advice has also been suggested by other researchers.

Pidgeon and O'Leary (1994) argue that a 'good' safety culture might both reflect and be promoted by at least four facets: 1) senior management commitment to safety; 2) shared care and concern for hazards and a solicitude for their impacts upon people; 3) realistic and flexible norms and rules about hazards; and 4) continual reflection upon practice through monitoring, analysis, and feedback systems (organisational learning).

The International Atomic Energy Agency (2002) argues that the following factors are the most important solutions to safety culture problems: 1) continuous safety problems, 2) effective communication channels, 3) management commitment, 4) effective planning system, 5) resource adequacy, and 6) skills and competencies.

Reason (1997) has linked weaknesses of 'safety culture' with organisational accidents in studies of disasters and has identified four critical aspects of a safety culture: a reporting culture, a just culture, a flexible culture and a learning culture. According to Reason, these factors interact to create an informed culture. Reason (1997) emphasises the importance of looking at organisational factors when viewing human error. As such, human error is more a consequence than a cause of organisational failures. Although safety culture was initially developed in response to major organisational accidents, the concept is now also widely applied to explain accidents at the individual level (Mearns et al., 2003).

The safety culture literature has also suggested different safety culture models. Geller (2001) presented a model that has three dynamic and interactive factors: person, behaviour, and environment. Changes in one factor will eventually impact the other two. Cooper (2000) developed a model similar to Geller's (2001), stressing the importance of empirical investigation of the links among personal, behavioural (practice), and situational aspects. Cooper considers these links to be interactive or reciprocal. In this way, people are neither deterministically controlled by their environments nor entirely self-determining; they influence and are influenced by their environments in a dynamic interplay. Both Geller's and Cooper's models were clearly influenced by social cognitive theory (Bandura, 1986). Grote and Künzler (2000) have also tried to illustrate links in a safety culture model between the safety management system, safety culture, and to the general organisational structure.

Because of the many overlapping elements of safety climate and safety culture, these concepts are generally considered to be highly related and overlapping in this thesis.

2.3 Safety climate assessment and outcomes

In the following some general issues relating to the assessment and outcomes of safety climate will be presented in two sections.

2.3.1 Safety climate assessment

The field of safety climate has emerged in four directions during the last three decades (Cooper & Phillips, 2004): 1) designing psychometric measurement instruments and ascertaining their underlying factor structure; 2) developing and testing theoretical models of safety climate to ascertain determinants of safety behaviour and accidents; 3) examining the relationship between safety climate perceptions and actual safety performance; and 4) exploring the links between safety climate and organisational climate.

The growing interest in safety culture has been accompanied by a need to develop assessment instruments (Nieva & Sorra, 2003) and therefore several questionnaire instruments have been developed to assess safety culture/climate in organisations. The resulting data from questionnaire measures can, for instance, be used for benchmarking purposes, trend analyses (Mearns, Flin & Whitaker, 2001), and a number of other improvement actions addressed by the IAEA (2002). In a review of the suitability of evaluation methods for specific safety culture improvement actions, the employee survey method earned the highest score compared to other methods (IAEA, 2002). However, others have been more critical of the survey method (e.g., Guldenmund, 2006).

Influenced by quantitative methods, the safety climate field has been dominated by the search for the right inventory or dimensions able to grasp the 'true priority of safety' (e.g., Anderson et al., 2000; Cooper & Phillips, 2004; Cox & Cheyne, 2000; Dedobbeleer & Beland, 1998; Flin et al., 2000; Griffin & Neal, 2000; Guldenmund, 2000; Rundmo, 2000; Williamson et al., 1997; Zohar, 2003). The aim is to assess the underlying safety culture through the use of safety climate surveys of workforce perceptions of the management of safety and the prioritisation of safety against other organisational targets (Flin, 2007, p. 658). Based on survey data, factor analysis is the most commonly used statistical method to determine the dimensional structure of safety climate (Guldenmund, 2000).

Flin (2007) argues for a set of universal or core variables that underpin safety climate across work sectors, but argues that specific factors can be considered for specific sectors. As such, safety climate dimensions can be categorised into universal versus industry-specific items. Often climate dimensions are the former, as they are applicable to all industries in which safety is a relevant issue (Zohar, 2003)

Zohar (2003) proposes a relatively strict approach to measure safety climate that only includes procedural features indicative of managerial commitments. However, four separate reviews of safety climate studies do illustrate several other topics are included within the safety climate domain. Therefore, no absolute agreement exists regarding which dimensions safety climate should consist of. The first two reviewed safety climate studies used in industry in general (Flin et al., 2000; Guldenmund, 2000), while the latest review studies have been conducted on the use of safety climate instruments in health care (Flin et al., 2006; Colla et al., 2005). In addition, Flin (2007) reviews many of these studies, paying special attention to the relevance of former studies on the assessment of safety climate in health care.

In a review of 15 studies, Guldenmund (2000) revealed that management was the most common dimension, followed by risk, safety arrangements, procedures, training, and work pressure. Flin et al. (2000) examined 18 instruments (11 overlapped with Guldenmund's study), revealing that the most common dimensions were related to management (72 percent of the studies), safety system (67 percent), and risk (67 percent). Furthermore, work pressure and competence appeared in one third of the studies.

In health care, Colla et al. (2005) discovered that nearly all nine surveys used five common dimensions of (patient) safety climate: leadership, policies and procedures, staffing, communication, and reporting. In the latest review, Flin et. al (2006) revealed that the following dimensions were the most common in health care: 1) management/supervisor, 2) safety systems, 3) risk perception, 4) job demands, 5) reporting/speaking up, 6) safety attitudes/behaviours, 7) communication/feedback, 8) teamwork, 9) personal resources, and 10) organisational factors.

A comparison of the four review studies does not indicate principal differences concerning the theme of safety climate dimensions in industry versus health care. According to Flin (2007), four 'core' dimensions from industry are regarded by researchers as central to the construct of safety climate in health care: 1) management commitment to safety, 2) supervisor commitment to safety, 3) safety system, and 4) work pressure. Flin (2007) further suggests that the reviews of safety climate *"lends some weight to the arguments for a set of universal or core variables that underpin climate across work sectors"* (p. 662).

It is also important to emphasise that reviews of safety climate studies reflect research traditions, not necessarily what *should* be included in surveys measuring safety climate. Meanwhile, definitions of safety climate may function as a guide regarding what to include or exclude in the measurement of safety climate.

Level of analysis is another classification of safety climate. Zohar (2003) suggested a multilevel perspective in the assessment of safety climate in organisations. As such, a climate survey might include both company-level and group-level items relating to practices. According to Zohar (2000), a fundamental principle in organisations is that they set their goals and develop strategies to reach these goals. Such goals and strategies consider the changing environment, while top-level management has the first responsibility of defining the appropriate organisational goals and strategies. Meanwhile, middle management is responsible for transforming and developing operating procedures and action guidelines (Zohar, 2000), which is further executed by line managers at the work-group level (Zohar & Luria, 2005) through interactions with subordinates (Zohar, 2000). This multilevel approach emphasises that all levels in the organisation have important safety functions and influence performance at the individual level through behavioural expectancies.

Sometimes inter-rater consistency has been suggested as a necessary criterion for the aggregation of safety climate scores at certain organisational levels (e.g., Schneider, Salvaggio & Subirats, 2002; Zohar, 2002). Consequently, intraclass correlation coefficients (ICCs) are often used to test consensus when members of a group or organisation sufficiently share perceptions of safety climate scales' threshold of homogeneity to index consensus (Klein et al., 2000, from Zohar and Luria, 2005). However, safety-outcome variables used to validate safety climate scales may often determine the level of analysis used. Objective outcome data such as organisational accident records may only be available at certain departmental levels. As such, the level on the outcome data will guide the level of aggregation of climate to that level (Flin, 2007).

2.3.2 Safety climate as a performance antecedent

Safety climate assessment is expected to predict safety performance. A recent study by Nielsen et al. (2008) demonstrated that safety climate improvement during a 12-month period was associated with simultaneous reductions in lost time accidents in two manufacturing plants. A key point during the improvement period was to improve managements' commitment to safety.

A study conducted in offshore environments partially also supported positive associations between safety climate and safety performance (Mearns et al., 2003). According to the authors it is becoming accepted that higher levels of safety climate is essential for safe operation and that safety climate emerge as positive predictors of unsafe behaviour or accidents.

In Zohar's (2003) and Flin's (2007) safety climate models, safety climate influence worker expectancies, safety behaviour, and—finally—adverse events. Consequently such factors can be expected outcomes of safety climate. Flin (2007) goes even further than Zohar (2003) to suggest that "safety climate is similar for both patient and worker adverse events" (p. 660). Flin (2007) adopts Zohar's model so that safety climate can predict adverse events in health care in addition to other industries. However, in health care, an adverse event can also include health care worker (self of other) events (DeJoy et al., 1995). Yet unlike Zohar (2003), Flin (2007) does not specify a link between supervisory safety practices and climate at the group level nor a link to how climate on the organisational level influences the lower level climate. Such links has however been suggested by Zohar (2003). What is innovative and interesting though, is that Flin (2007) incorporates patient injury so that her proposed model fits health care settings as well as other industries. A recent study conducted in 91 hospitals supports that safety climate also influences adverse events relating to patient safety. This study, conducted by Singer et al. (2009), demonstrated significant associations among frontline personnel between safety climate and a lower risk of experiencing patient safety indicators.

Accident rates may present an indisputable direct outcome measure for safety climate and safety interventions. Still, accident statistics may create problems for several reasons—namely, accidents are normally rare, may not be due to job incumbents, and are not always consistently recorded. Based on these problems, as well as previous research (Dejoy, 1994; Hofmann, Jacobs & Landy, 1995; Janssens, Brett & Smith, 1995), Thompson, Hilton, and Witt (1998) recommended the use of self-reports of safety behaviour and perceptions as alternative criterion measures for determining workplace safety. This alternative is also naturally associated with measurement bias and challenges. Yet the scientific quality of self-reports can be improved with different forms of validity and reliability techniques.

2.4 Improving organisational safety

Although many approaches can be used to improve safety, the focus here is mainly related to improved safety via the social systems of organisations. The social system of organisations includes both aspects related to organisational culture, social structures, organisational climate, and work relations between management and employees (Ekvall, 1983, from Guldenmund, 2000). When it comes to safety, social factors that safety interventions aim to improve may e.g. be related to safety culture, safety climate, safety motivation, and safety behaviour.

DeJoy (2005) defines divergent approaches to managing and improving workplace safety as behavioural change versus cultural change. The behavioural approach mainly refers to behaviourism (Skinner, 1938). Essentially, in the behaviour-based approach, “applied behaviour analyses hold that behaviour is under the control of environmental contingencies” (DeJoy, 2005, p. 107). The behavioural approach is considered a “bottom-up” approach, while the cultural approach to safety is considered a “top-down” approach. The cultural approach heavily relates to management and organisational behaviour theory (DeJoy, 2005), including terminology and methods borrowed from ethnography. The aim according to this approach is often to change fundamental values and beliefs of the organisation to make lasting improvements on safety. According to DeJoy, organisational culture is thought to be self-perpetuating and slow to change (DeJoy, 2005, p. 108). In practice, behavioural and cultural approaches to safety are often integrated (DeJoy, 2005).

Safety interventions implemented over a period of time is often organised or defined as safety programmes. A safety programme can be described as a dynamic set of intervention activities implemented at a worksite where the aim is to prevent incidents and accidents at the workplace. Safety programmes typically include activities such as safety training, equipment and housekeeping inspections, safety meetings, and safe behaviour observations (Lyer et al., 2005).

According to Cooper (2000), several factors may affect efforts to improve safety in organisations. Such factors may relate to degrees of commitment to safety at various hierarchical levels, congruence between safety toward other goals (i.e., productivity), communication and feedback, training abilities, task complexity, lack of resources, work pace, and job design issues.

According to Lund and Aarø (2004), safety interventions should affect not only individuals, but also social norms and cultural factors. The challenge is not only to determine the optimal combinations of preventive measures and implement them effectively, but also to develop a clever marketing strategy (Vecchio-Sadus & Griffiths, 2004). Thus, the success of safety-related improvements will depend on organisations' ability to successfully implement such recommendations. If successful, it is reasonable to expect that some changes may appear in workers' individual behaviour and the safety culture of an organisation.

Changing thoughts and behaviours of individuals is constrained by social cognitive mechanisms that characterise human behaviour. Bandura's (1986) social cognitive theory may as such add knowledge to behaviour change. According to this perspective, interplay occurs between people and the environment, which is dynamic and reciprocal; as such, people's actions are not entirely determined by situational or personal characteristics (Cooper, 2000).

Contrasting perspectives of organisational culture is in this thesis used as a framework for understanding safety culture in organisations. As such, it is acknowledged that integration around safety as a value orientation can vary both within and among organisations. Some organisational theorists of organisational culture suggest that culture to a certain degree is manageable, but relatively stable (e.g., Schein, 2004), while others suggest that managing organisational culture is difficult as the culture is continuously created by the organisation's members (e.g., Geertz, 1973). Based on these contrasting perspectives, it can be expected that safety culture is improvable and vice versa—that managing, improving, and directing safety culture are difficult. Another point is that coherence around improvement efforts may be necessary, although not sufficient, to bring about substantial change (Davies et al., 2000). As safety climate is thought to reflect the underlying safety culture, these viewpoints are also applicable in the studies of safety climate. It is reasonable to believe that improvement of safety culture to some degree will be simultaneously reflected in improvement of safety climate.

2.5 Integration of concepts

"Organizational culture and climate are conceptually and empirically closer than had previously been assumed" according to Ashkanasy, Wilderom, and Peterson (2000, p. 129). Similar points have also been emphasised by other researchers (Denison, 1996; Moran & Volkwein, 1992; Schneider, 1990). Safety climate has mainly evolved from organisational climate research while grasping a stronger focus on safety than general organisational climate research (Kopelman, Brief & Guzzo, 1990). Likewise, safety culture theory developed based on organisational culture research to explain more safety-specific issues, often in relation to accidents (e.g., IAEA, 1986). Figure 1 illustrates a simplified overview of central concepts presented in this thesis and the major relation between them.

The focus of this thesis is mainly safety climate. However, one of the studies concerns a safety culture programme. As safety climate to some degree is considered a measure of safety culture, safety culture is at some level also addressed in the safety climate studies.

Figure 1 illustrates (nomothetic) relations between major concepts addressed. Safety climate and safety culture are generally believed to influence safety performance (e.g., levels of safety behaviour, perceptions of safety, and accident rates).

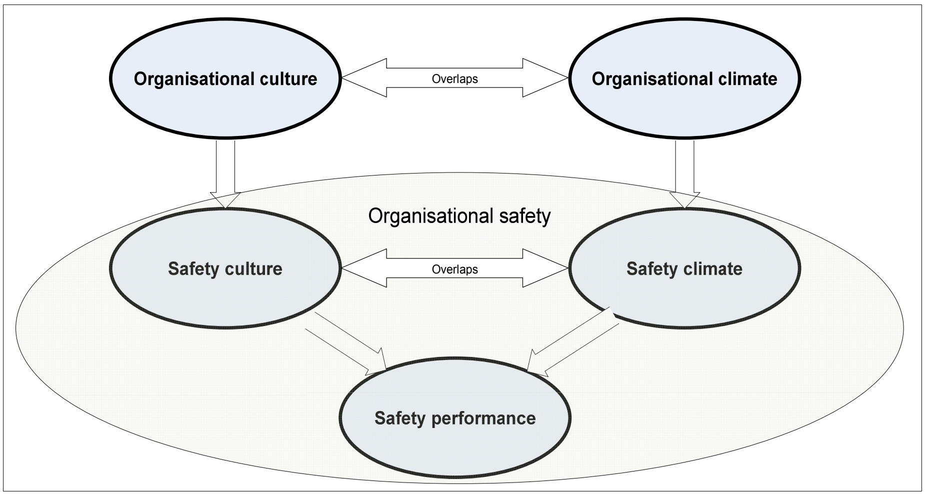

Figure 1. Overview of central concepts.

Based on earlier studies, some general causal models have been specified in this thesis regarding the influences of safety climate. The first four papers address issues relating to safety climate[5]. In papers 1, 2, and 3, it is expected that safety climate positively influences safety outcomes related to safety performance (Figure 2), while a tentative model based on multilevel safety climate reasoning is developed for paper 4 (Figure 3).

Figure 2. General working model used in studies of safety climate (papers 1, 2, and 3).

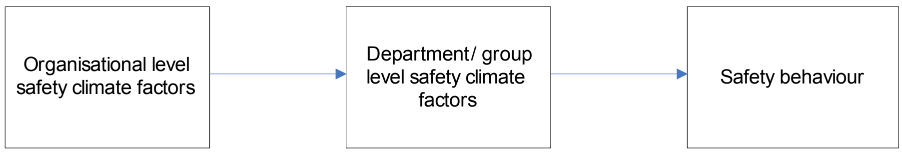

Figure 3. Tentative principal model specifying a link between higher and lower level safety climate factors and safety behaviour (paper 4).

Since a mixed method approach is used in the development of concepts and model in paper 5, no a priori working model is developed in this study.

[5] In the beginning of this research I considered labelling measures of 'safety climate' as measures of 'safety culture'. This reasoning was based on the many overlaps between the concepts and therefore the term 'safety culture dimensions' are used in paper 1. However, since it has become more common within the research field to use the term 'safety climate' when using a survey approach, this term is consistently used in descriptions of dimensions covering safety climate in the first part of the thesis and in papers 2, 3 and 4.

3 Methodology

3.1 Overview of study design

The most common method in safety climate studies is the survey method based on psychometrics. Thus, the survey method will be used for the studies on safety climate. Studies of safety culture often suggest using multiple indicators. Therefore, a mixed method approach is used in the study of the safety culture programme.

An overview of the conducted studies is presented in Figure 4. Safety climate studies are conducted as part of papers 1, 2, 3, and 4. The research design in papers 1 and 2 are based on two measurement waves conducted at a relatively large regional hospital, while paper 3 is based on a similar design involving measurement waves among platform workers at the Norwegian Continental Shelf. In paper 4, safety climate data is from the same questionnaire wave as in paper 1 in addition to a survey conducted in a petroleum company[6]. Paper 5, involves a mixed method approach in the study of a large safety culture programme.

[6] The hospital survey samples in paper 1 and 4 are from the same questionnaire sample/measurement.

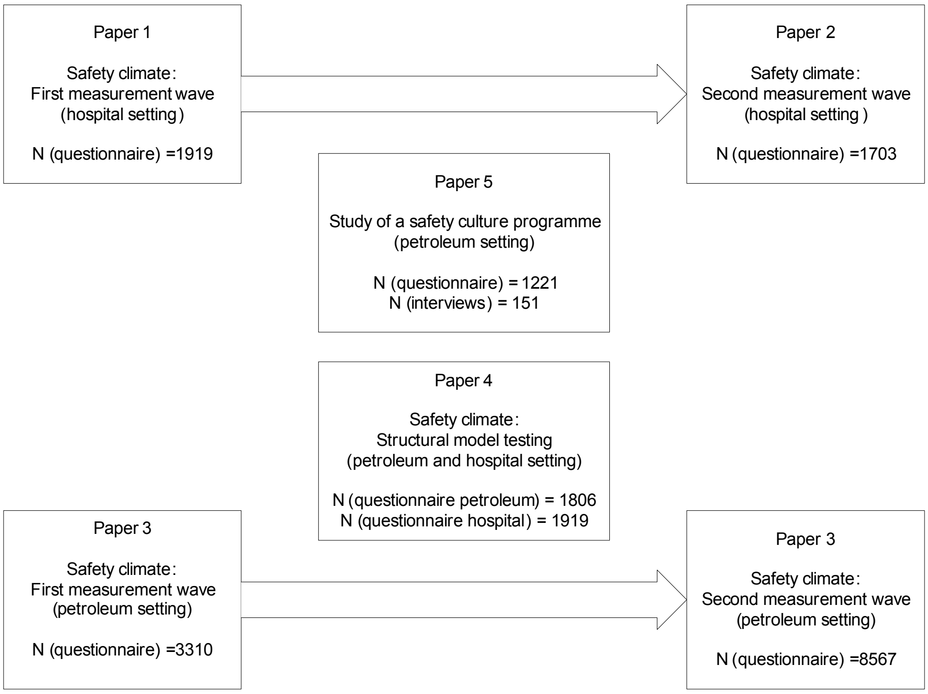

Figure 4. Overview of papers and data studied in the thesis.

3.2 Aim of papers

The aims of the papers were as follows:

Paper 1.

- Assess the validity and reliability of Hospital Survey on Patient Safety Culture (HSOPSC) in a Norwegian health care setting.

Paper 2.

- Investigate the psychometric properties of HSOPSC at two measures.
- Study longitudinal change versus stability on measurement concepts during a two-year measurement period.

Paper 3.

- Examine the psychometric qualities of the Norwegian offshore risk and safety climate inventory (NORSCI) at two measurements.

- Compare employee perceptions of safety climate during a two-year measurement period.

Paper 4.

- Explore the possibility of identifying comparable safety climate concepts in health care and petroleum.

- Develop and test the possibility of a cross-industrial structural model in the two sectors.

Paper 5.

- Gain insight into important factors that influence and mediate the effects of a large-scale safety culture programme.

- Develop and test a hypothetical structural model that illustrates important influences of the programme.

3.3 Psychometric theory of measurement

The purpose of psychometric theory is to develop understandings of psychological and social phenomena by quantifying them. Since social and behavioural phenomena have a variety of different forms, different assessment strategies are often needed according to psychometric theory. Another challenge is that social and behavioural phenomena are not always directly observable. Psychometric theory suggests the need for understanding how to measure both concrete and abstract phenomena. To measure certain issues (e.g., a person's sex), no theory or complex measure is needed. However, for more complex issues, deeper theoretical understandings combined with more sophisticated methods are often necessary (DeVillis, 2003).

Since theoretical variables are not directly observable, collections of items are often combined into composite scores. Such measures are often referred to as scales or dimensions and are commonly developed by the use of factor analysis (DeVillis, 2003; Netemeyer et al., 2003). The adequacy of a scale addresses different forms of validity and reliability concerns (Devillis, 2003). Items incorporated into a dimension should, for example, have a certain level of homogeneity (Netemeyer et al., 2003). Because of the difficulty of developing solid measurements, psychometric theory stresses that dimensions should meet different criteria. The level of accordance on such are often referred to as the psychometric qualities of an instrument. A high level of such qualities is necessary to grasp levels of theoretical concepts and distinguish concepts from one another (Devillis, 2003). As a result, some of the most central concepts relating to the psychometric properties of measurements will be presented in the following[7].

Latent variable. The underlying phenomenon of a construct that a scale is supposed to reflect is often called the latent variable. The purpose of the latent variable is to explain the variance in items; thus, the latent variable is regarded as a cause of the item's score. The quality of the latent variable depends on several criteria according to psychometrics; generally the latent variable must be valid and reliable (Devillis, 2003).

Reliability. Reliability is concerned with the internal consistency and homogeneity of the items within the scale. Reliability is typically measured with Cronbach's (1951) coefficient alpha, α, which can range from 0.0 to 1.0. A low alpha score indicates a high level of error and a less reliable scale, as opposed to a high score. Alpha scores should normally not fall below .60 to be considered acceptable. However, the evaluation of the alpha score should also be considered in relation to the theoretical concept a measurement is supposed to reflect as well as other validity concerns (Devillis, 2003).

[7] For a broader presentation of psychometric theory and ongoing debates see, for example, DeVillis (2003) or Netemeyer et al. (2003).

Content validity. Content validity concerns the extent to which a specific set of items reflects a theoretical domain (DeVillis, 2003) and how well a measure actually measures the construct it is intended to measure (Netemeyer et al., 2003). Content validity depends on the evidence of reliability and identification of a theoretical concept through the measurement. In addition, a number of procedures have been developed for establishing construct validity; some of them will be presented in the following (Netemeyer et al., 2003).

Construct validity. Construct validity concerns the theoretical relationship a variable has compared to other variables—namely, the extent to which a measure "behaves" with regard to other measures (DeVillis, 2003). Although some disagreement exists with regards to what is classified under the rubric of construct validity (Netemeyer et al., 2003), some examples of validity assessments related to construct validity are described in the following paragraphs.

Convergent validity. Convergent validity refers to the degree to which measures designed to measure interrelated measures converge with such measures. Convergence is said to be found when measures are highly correlated when this is expected (Netemeyer et al., 2003).

Discriminant validity. Discriminant validity refers to the degree to which similar, but conceptually different measures are related. Low or moderate correlations between measures are often preferred for evidence of discriminate validity (Netemeyer et al., 2003).

Criterion-related validity. Criterion-related validity is concerned with the level by which a variable predicts other types of relevant variables (often referred to as predictive validity) or the level of concurrence with other expected types of measures assessed over a similar period of time (often referred to as concurrent validity) (DeVillis, 2003; Netemeyer et al., 2003).

Nomological validity. Nomological validity is concerned with the structure between constructs in which the theoretical network defined is confirmed by the data; measures should be empirically and significantly related as expected (Netemeyer et al., 2003).

Another important point according to psychometric theory is that validity concerns is an ongoing process; one study supporting a construct's validity is not sufficient to finally settle that the measure has been validated. The usefulness of measures depends on the repeatability of measures; measures should perform reliably under similar testing conditions (e.g., reproducing the dimensional structure of standardised surveys) (Netemeyer et al., 2003).

Validation is a cumulative process; measures validated in one setting need to be validated in other settings (e.g., different organisations and cultures). Support for validity and reliability is further strengthened when evidence is provided over different time periods. This in turn may contribute to evidence supporting the idea that similar concepts can be monitored over time to identify organisational trends on measurements. Such considerations will be considered highly important in this thesis. Thus, a variety of psychometric techniques will be used; when possible, such techniques will be repeated on different samples prior to the investigation of longitudinal trends. For details see section 3.8 and the method sections in each of the papers in part II.

3.4 Samples

Samples in this thesis are from specialised health care and petroleum industries based in Norway.

Paper 1 is based on a first measurement wave conducted at a relatively large Norwegian university hospital offering specialised health care. The target group included health care workers at the hospital as well as other personnel employed primarily in the same working environment as the health care personnel. A total of 1919 workers answered the survey, resulting in a response rate of 55 percent. Of these respondents, 89 percent had direct patient contact, whereas 62 percent worked between 20 and 37 hours per week. Nurses with and without specialist education represented 45 percent of the sample.

Paper 2 is based on the first measurement wave from paper 1 in addition to a second measurement wave conducted two years later. In the follow-up measurement, a total of 1703 workers answered the survey, resulting in a response rate of 49 percent; 89 percent of these had direct patient contact, whereas 60 percent worked between 20 and 37 hours per week. Moreover, 42 percent of the total sample at the second measurement represented nurses with or without specialist education.

Paper 3 is based on self completion questionnaire data from two measurement waves aimed at personnel on offshore oil platforms on the Norwegian Continental Shelf. The time between the two measurements was two years, and the number of participating platforms/fields was 52. The response rate was 55 percent (N = 3310) for the first measurement and 50 percent (N = 8567) for the second. Due to an extension of the survey from two weeks in 2001 to six weeks in 2003, the samples varied considerably in size, but were considered to be representative at both measurement times.

In paper 4, questionnaire surveys were conducted at a large regional hospital (same sample as in paper 1 and first measure in paper 2) and a large petroleum company[8]. For the petroleum company, the response rate was 52 percent, with 1806 workers answering the survey. Companies in the petroleum sector often use contractors; therefore, this sample also included 296 employees working in 4 different companies under contract for the petroleum company. In the petroleum sample, 44 percent were employed in jobs offshore and 66 percent onshore. The share of workers having an administrative position was higher onshore (59 percent) than offshore (28 percent).

To investigate how the safety programme functioned in different settings, the aim of the sample strategy in paper 5 was to investigate various types of departments and work areas in an organisation that implemented a comprehensive safety culture programme. A total of 151 qualitative interviews as well as fieldwork were conducted on three offshore installations, one onshore gas plant, and different office departments within the organisation. In addition, a questionnaire survey was developed and carried out on seven offshore installations, one gas

[8] The petroleum company is the same as in paper 5.

plant, and six onshore units. The survey yielded a response rate of 40 percent (N = 1221). In the survey sample, 76.6 percent of the respondents worked on offshore installations, 19 percent had management responsibility, 86.7 percent had participated on a two-day kickoff gathering, 34.5 percent were employed in a contractor company, and 58.3 percent were at least 40 years old. The qualitative interviews and the survey were carried out one to two years after the respondent units initiated the safety culture programme. Furthermore, focus discussion groups were carried out immediately after the first (N = 11) and second (N = 12) two-day kickoff gathering implemented in the organisation.

3.5 Instruments

Hospital Survey on Patient Safety Culture (HSOPSC), developed by Sorra and Nieva (2004), was used to assess safety climate in papers 1 and 2. HSOPSC is also used as part of the study described in paper 4. HSOPSC was translated into Norwegian[9]. HSOPSC assesses safety climate in health care settings using seven dimensions concerning safety climate at the unit level: 1) communication openness; 2) feedback and communication about error; 3) organisational learning–continuous improvement; 4) supervisor/manager expectations and actions promoting safety; 5) non-punitive response to error; 5) teamwork within units; 6) staffing; 7) supervisor/manager expectations & actions promoting safety, and three dimensions at the hospital level; 8) handoffs and transitions, 9) management support for patient safety, and 10) teamwork across units. In addition, HSOPSC includes four outcome measures—two multi-item scales (overall perceptions of patient safety and frequency of events reported) and two single-item scales (patient safety grading and number of events reported over the past 12 months). All measurement concepts in HSOPSC are measured using 5- and 6-point Likert-scales. Furthermore, some items concerning background demographics are included. One outcome measure—stop working in dangerous situations (e.g. *I ask my colleagues to stop work*

[9] See paper 1 for more details.

that is dangerously accomplished)—was added to HSOPSC, and assessed as part of paper 2.

In paper 2, HSOPSC was also used as part of the second measurement wave. The outcome measure stop working in dangerous situations was also included.

In paper 3 the Norwegian Offshore Risk and Safety Climate Inventory (NORSCI) was developed to assess safety climate in two measurement waves. Five dimensional factors measure safety climate: 1) safety prioritisation, 2) safety management and involvement, 3) safety versus production, 4) individual motivation, and 5) system comprehension. In addition analyses of a risk perception scale as well as accident rates that are standardised to correspond with one million man hours worked at the platform/field level, are analysed in paper 3.

In paper 4, HSOPSC is distributed to a sample in a petroleum company. Additional data from the first measurement at the hospital are also analysed. Prior to distributing HSOPSC to the petroleum sample, adaptations were made, including that the term *patient* was removed from certain items (for example, the original item "my supervisor/manager seriously considers staff suggestions for improving patient safety" was changed to "my supervisor/manager seriously considers staff suggestions for improving safety"). Still, for most of the items, there was no need for revision as the meaning generally relates to cross-industrial settings. A criterion measure for the likelihood that an employee would stop working in dangerous situations was also incorporated. After these adaptations to the questionnaire, a total of 37 items measured on Likert scales were used to assess safety climate in both sectors incorporating five safety climate dimensions and one safety behaviour dimension: 1) supervisor/manager expectations and actions promoting safety; 2) learning, feedback, and improvement; 3) teamwork within units; 4) organisational management support for safety; 5) transitions and teamwork across units, and safety behaviour (stop working in dangerous situations).

Paper 5 measured five concepts for inclusion in a structural model: 1) participation on a two-day kickoff, 2) effectiveness of program implementation, 3) personal program commitment, 4) safety behaviour change, and 5) safety culture change. The background for the development of these measurement concepts was based on the mixed method approach described in section 3.6.

3.6 Mixed method approach

Contrary to safety climate research, the development of specific safety culture programmes is a relatively new phenomenon in the Norwegian petroleum industry, which again has consequences for the development of study design. Studying a specific safety culture programme demands a more data-driven approach compared to safety climate studies that build on three decades of research. Therefore, a data-driven approach is used in the first phase of the safety programme study to gather information about the programme content and implementation. The aim is that knowledge from the first phase will lead to deduction and theory-driven exploration of hypothesis in the second phase of the study. Qualitative data, programme characteristics, and previous research will be the basis for the structural model developed and tested on questionnaire data.

Qualitative and quantitative methods represent different ontologies (Tashakkori & Teddlie, 1998) that, when combined, contribute valuable insights into the effects and dynamics of safety interventions.

The qualitative parts of the study will be described in the following paragraphs while other methodological issues relating to paper 5 are described in section 3.4, 3.5, and 3.8, and in the paper.

The qualitative interviews (N=151) were carried out in interviewees' workplaces. As mentioned, both the interviews and the survey were carried out one to two years after the respondent units initiated the safety programme to investigate various types of departments and work areas. Leaders and employees representing both contractor companies and the operator company at each workplace were interviewed. The interview sample also included safety deputies and employees representing unions.

A semi-structured interview guide was developed before the interviews were conducted. The focus of the interview guide was interviewees' thoughts, understandings, experiences, and perceptions about the safety program design and implementations in the context of the organisation in which they work. For example, concrete topics in the interview guide related to specific contents of the safety programme, level of implementation, worker and leader involvement, satisfaction and concerns regarding the programme, problems and challenges regarding implementation, and questions concerning cultural and behavioural change.

Fieldwork was also conducted, lasting for approximately 6 days each and spread over three offshore installations—one gas plant and two onshore units. The fieldwork consisted of stays in the departments of contractors and operators, informal discussions during coffee breaks, etc. During most of the fieldwork, researchers conducting the study also participated in meetings with safety deputies and managers.

Concerns regarding validity should be stressed at different stages of the qualitative research process (Kvale, 1996; Miles & Huberman, 1994). In order to validate the findings at the unit level, summary field notes were written for each work unit. These field notes were handed to key personal in each unit and functioned to some degree as validity checks of the results. This approach made it possible to assess dynamics related to individual and work characteristics, which again is related to the implementation and effects of the programme.

3.7 Improvement efforts

In paper 2, some improvement efforts were implemented between measurements that could possibly influence the safety climate level: 1) establishment of a new patient safety unit, 2) establishment of new positions as quality coordinators in all major clinical areas, and 3) implementations of a new electronic system for reporting of adverse events. Other improvement efforts were to some degree also implemented; however, contents and levels of such were not monitored through the research design used.

Given the relatively large population of workers on offshore platforms in the North Sea, improvement efforts between measures conducted in paper 3 were not tracked or monitored. Between the baseline and follow-up measurement, oil prices were high. Generally, the industry was also distinguished by a positive drive and energy between the measures.

In paper 5, the safety culture programme implemented in a petroleum company was defined to last for more than three years. The aim of the programme was to improve safety behaviour and safety culture during the programme period. Five soft barriers were defined in the safety programme to enhancing safety culture and safety behaviour: 1) correct prioritisation, 2) compliance, 3) open dialogue, 4) continuous risk assessment, and 5) caring about colleagues. Descriptions of these barriers and a more thorough description of the programme are presented in paper 5.

3.8 Statistics

An overview of statistical methods applied in the different papers is presented in the following table, followed by a description of the different statistics.

Table 1
Overview of statistical methods used in the different papers

	Paper				
Analysis	1	2	3	4	5
Exploratory factor analyses			X		X
Confirmatory factory analyses (CFA)	X	X	X	X	X
Hypothetical structural model testing using SEM				X	X
Cronbach's alpha	X	X	X	X	X
Correlation (Pearson's r)	X		X	X	
Analysis of variance (ANOVA)			X		
Multivariate analysis of variance (MANOVA)	X	X	X	X	
Regressions analyses	X				
T-test (two-tailed)	X	X		X	
Intraclass correlation coefficient (ICC)			X		

In paper 1, confirmatory factor analysis (CFA) was utilised to investigate the fit of the proposed factor structure. Cronbach's alpha was determined to examine the internal consistency of dimensions. Intercorrelations (Pearson's *r*) among concepts and multiple analysis of variance (MANOVA) were conducted to investigate discriminant validity. Regression analysis was examined to verify the degree to which the safety climate dimensions influenced the outcome variables included in HSOPSC.

With the exception of regression analyses, the same statistics were used in paper 2 as in paper 1. However, in paper 2, MANOVA was conducted to examine if *T*0/*T*1 had overall influences on HSOPSC concepts between *T*0 and *T*1. In addition, independent sample t-tests (two-tailed) were utilised to investigate changes between *T*0 and *T*1 for separate safety climate dimensions.

In paper 3, principal component analyses and varimax rotation were used to explore the dimensional structure of safety climate in the first measurement sample. Thereafter, the model fit of the structure that emerged through the exploratory analyses was tested by applying SEM confirmatory factor analyses on both measurement waves separately. Internal consistency was tested using Cronbach's alpha. Discriminant and criterion validity were analysed using Pearson's *r*. The associations between safety climate and risk perception were tested separately for the two years. In order to keep the data on the same level of analysis, the correlations among accident rates, risk perception, and safety climate dimensions were aggregated at the platform level and performed separately for the two years. Intraclass correlation coefficients were used to test consensus on platforms[10]. MANOVA was used to test whether or not an overall change occurred in employee perceptions of safety climate in 2001 and 2003 and to test which of the dimensions showed significant differences on various demographic

[10] Within a group, agreement may be assessed using r_{wg} that should meet or exceed 0.70 to indicate and justify within group agreement (Klein et al., 2000, from Zohar and Luria, 2005).

variables. The MANOVA, including demographic variables, was performed separately for the two years.

In paper 4, the “don’t know” category added to seven items (prior to distribution to the petroleum sample) was treated as missing values before any of the subsequent analyses were conducted. Mean composite scores for the dimensions were created after development of the final factor structure and after reversing the coding for the reverse items. SEM was employed to examine the hypothetical structural model. Testing of the structural model was separated according to major categories in both the hospital (nurses versus non-nurses) and the petroleum sample (onshore versus offshore). To determine if factor scales yielded acceptable alpha coefficients and internal consistency, Cronbach’s alpha was estimated. MANOVA was used to test whether an overall difference in employee perceptions of safety climate and safety behaviour existed. T-test statistics were estimated to determine if the mean differences were significant for each measurement concept. Pearson’s r was estimated separately for each sector to investigate correlations among concepts.

Paper 5 employed exploratory factor analyses (principal component analyses) to develop measurement concepts that reflected five theoretical domains that were developed. Robust maximum likelihood was thereafter used as the estimation method to replicate the measurement model and in the assessment of the structural model. As part of the scale development, mean, standard deviation, and Cronbach’s alpha were computed for all measurement concepts.

To evaluate model fit in the structural equation modelling, several fit indices were assessed in the different studies when applying SEM. At least three of the following guidelines were applied in the studies, although not all of the indices were applied in all of the papers where SEM was applied: Root Mean Square of Error Approximation (RMSEA) $< .10$, Non Normal Fit Index (NNFI) > 0.95, Comparative

Fit Index (CFI) > 0.90, Incremental Fit Index (IFI) > .90, critical N (CN) > 200, Non Normal Fit Index (NFI) > 0.90[11].

It is also common to use the Satorra-Bentler scaled χ^2 to evaluate model fit. However, the problem with χ^2 is that almost all models are evaluated as incorrect as sample size increases (Bentler & Bonnet, 1980). Due to the relatively large samples assessed in the various studies, χ^2 was not used to evaluate model fit.

Statistical software packages were used to conduct analyses. Confirmatory factor analyses and assessment of SEM were conducted with SEM made simple (STREAMS) for the LISREL analyses in papers 1 and 3, AMOS 7.0 in papers 2 and 4, and LISREL 8.70 in paper 5. Additional statistics were assessed using SPSS.

[11] More thorough information about some of these indices is presented in paper 5.

4 Results

4.1 Summary of paper 1

Olsen, E. (2008). Reliability and Validity of the Hospital Survey on Patient Safety Culture at a Norwegian Hospital. In J. Øvretveit and P. J. Sousa (Eds.), *Quality and Safety Improvement Research: Methods and Research Practice from the International Quality Improvement Research Network (QIRN)* (pp.173-186). Lisbon: National School of Public Health.

The objective of the study was to examine the psychometric properties of HSOPSC in a Norwegian hospital setting. Confirmatory factor analyses indicated that the factorial model was well fitted to the data. Intercorrelations among concepts and MANOVA further supported the discriminate validity of measurement concepts. Analysis of internal consistency was generally satisfactory, but the internal consistency was slightly lower than recommended for the dimension organisational learning—continuous improvement. Patient safety grade and overall perceptions of safety had the best fit as outcome variables, while the number of events reported (during the last 12 months) was not suited as such. Generally, results indicated that the psychometric properties of HSOPSC are satisfactory and that the instrument can be used in Norwegian hospital settings.

4.2 Summary of paper 2

Olsen, E., & Aase, K. (2009). Validity and reliability of the Hospital Survey on Patient Safety Culture and exploration of longitudinal change at a hospital. *Safety Science Monitor*, submitted.

The objective of the study was to investigate the psychometric properties of HSOPSC for two measures and study longitudinal change versus stability for measurement concepts during the measurement period (two years). Confirmatory factor analysis indicated that the HSOPSC factor structure was satisfactorily replicated for both the first and second measurement. Generally speaking, the psychometric properties of the instrument were considered satisfactory.

Three of the mean scores for the safety climate dimensions improved (supervisor/manager expectations & actions promoting safety, teamwork within hospital units, nonpunitive response to error), two were reduced (staffing, organizational management support for patient safety), and five dimensions had no significant change (organizational handoffs and transitions, teamwork across units, feedback and communication about error, communication openness, organizational learning—continuous improvement). Small significant improvements were observed for the patient safety grade and stop working in dangerous situations, but not on overall perceptions of patient safety. The results demonstrate that the safety climate level was relatively stable during the period, indicating that improvement efforts had relatively little impact on the safety climate dimensions.

4.3 Summary of paper 3

Tharaldsen, J. E., Olsen, E., & Rundmo, T. (2007). A longitudinal study of the safety climate on the Norwegian continental shelf. *Safety Science, 46*, 427-439.

The objective of the study was to examine the psychometric qualities of a questionnaire (NORSCI) and whether employee perceptions of safety climate changed over time. A combination of exploratory factor analysis and confirmatory factor analysis resulted in a safety climate structure consisting of five dimensions; 1) safety prioritisation, 2) safety management and involvement, 3) safety versus production, 4) individual motivation, and 5) system comprehension. Structural equation modelling combined with other statistics indicated that the suggested factor model fitted the data in the first and second measurement. Safety climate improved from the first to the second measurement on four dimensions. Safety prioritisation, and safety versus production improved most, followed by safety management and involvement, and individual motivation. The last dimension, system comprehension, showed a minor decline. The results demonstrated that the safety climate level in general changed and improved during the period.

4.4 Summary of paper 4

Olsen, E. (2009). Exploring the possibility of a common structural model measuring associations between safety climate factors and safety behaviour in health care and the petroleum sectors. *Accident Analysis and Prevention*, resubmitted.

The aim of this study was to explore the possibility of identifying general safety climate concepts in health care and petroleum and to develop and test the possibility of a cross-industrial structural model in those two sectors. Exploratory factor analysis revealed six identical cross-industrial measurement concepts—five measures of safety climate and one of safety behaviour: 1) learning, feedback, and improvement; 2) teamwork within units; 3) supervisor/manager expectations and actions promoting safety; 4) transitions and teamwork across units; 5) organisational management support for safety; and 6) stop working in dangerous situations. The factors' psychometric properties were explored with satisfactory internal consistency and concept validity. Based on these results a common cross-industrial structural model was developed and tested using structural equation modelling (SEM).

Model assessment indicated a good fit for two sub-categories in health care (nurses versus other personnel) and offshore workers in the petroleum sample. However, the model did not adequately fit onshore workers in the petroleum sample. Based on these findings, the model generalisation was limited to the total health care sample and offshore workers in the petroleum sample. Hence, results support that a common cross-industrial structural model could be identified among health care workers in a hospital setting and among offshore petroleum workers.

The most significant contributing variables in the structural model were organisational management support for safety and supervisor/manager expectations and actions promoting safety. These variables indirectly enhanced safety behaviour by the mediating roles of transitions and teamwork across units, teamwork within units, and learning, feedback, and improvement.

4.5 Summary of paper 5

Olsen, E., Bjerkan, A. M., & Nævestad, T. O. (2009). Modelling the effects of a large-scale safety culture program: A combined qualitative and quantitative approach. *Journal of Risk Research*, *12*, 1-21.

Two aims were defined: 1) gaining insight into important factors that influence and mediate the effects of large-scale safety program and 2) developing and testing a hypothetical structural model that illustrates important effects of the safety program. Based on the qualitative results, five theoretical domains were defined as important concepts to be incorporated into a hypothetical structural model: 1) participation in a two-day kickoff; 2) effectiveness of programme implementation (the degree to which workers think the programme is effectively implemented and are satisfied with programme characteristics as well as the degree to which leadership supports the implementation); 3) personal programme commitment (the degree to which workers follow up their personal programme commitment); 4) safety behaviour change (the degree to which workers believe their safety behaviour has changed following programme implementation); and 5) safety culture change (the degree to which workers agree that the safety programme has improved the company's safety culture).

Separate exploratory factorial analysis revealed that the theoretical domains developed could be replicated in the data, thereby supporting the validity of such theoretical and measurement concepts. Confirmatory factorial analyses were conducted to further validate the five measurement concepts developed with exploratory factorial analyses. Goodness-of-fit indices indicated that the measurement model fitted the data. In addition the reliability coefficients were generally satisfactory.

Although SEM indicated that the suggested structural model fitted the data, two of the hypothesised influences from personal programme commitment were not significantly supported. These non-significant path coefficients contrasted with the qualitative data; therefore, the model was modified and re-estimated. The fit indices of the modified model were adequate, supporting all hypothesised influences.

The final model developed illustrates the significance of personal programme commitment and the effectiveness of programme implementation for the level of change regarding safety behaviour and safety culture. Another significant finding was that participation in the two-day kickoff had two positive and one negative (direct) path estimate. I was also expected that safety behaviour change would influence safety culture change and vice versa, and this expectation was confirmed in the study.

5 Discussion

This thesis contributes to empirical investigations of safety climate and safety culture. The studies conducted have been structured through five empirical papers; the first four investigated aspects with regard to safety climate, while in the last paper a safety culture improvement programme was explored. This chapter addresses some general considerations in two primary sections: 1) measurement issues and 2) trends, models and safety improvements across sectors.

5.1 Measurement issues

Several analyses have been conducted in this thesis to investigate the psychometric properties of applied measurement concepts. Factor analysis is important in the process of developing and validating concepts. Furthermore, other forms of analysis have supplemented factor analysis and functioned as validity checks toward different validity types. These analyses have been conducted to reassess and reinvestigate the factorial model applied in the different papers. For instance, the analyses applied have involved correlations (Pearson's *r*) to examine the discriminant and convergent validity among measures, MANOVA and ANOVA to examine discriminant validity, and regression analyses and structural model assessments (using SEM) to investigate structural relations between concepts (nomological validity) and criterion-related validity. Although different forms of validity concerns have been thoroughly explored in all of the papers, some issues still need to be raised concerning methods applied.

Monitoring safety climate over time has been a central topic in two of the papers. As such, the possibility of social desirability bias needs to be addressed. Social desirability bias refers to the tendency of some people to respond to items more as a result of their social acceptability than their true feelings (Podsakoff, MacKenzie, & Podsakoff, 2003). This could be a problem in a longitudinal assessment of safety climate if workers overestimate the safety climate level. Yet the problem of social desirability is less susceptible to safety climate research in general compared to attitudinal questionnaires because safety climate addresses social perceptions, not personal components (Seo, Torabi, Blair & Ellis, 2004). However, one concern involved in conducting multiple measurements waves is that workers think they must respond in a correct manner—that is, to satisfy management needs to confirm the success of improvement efforts. To compensate for this possibility, neutral letters of information have been distributed along with questionnaires in the conducted studies.

Other important issues in social research are sample size and response rate. Samples should represent the target samples specified so that safety climate can be monitored over time. The issue of sample size is particularly important in papers 2 and 3, where the response rate was approximately 50 percent; this rate may be considered a threat to the studies. However, investigation of the samples studied does reveal a similar spread in background variables in the first and second measurements of both studies. The relatively large sample sizes also decrease the possibility of Type II errors[12], although some concern is warranted in regard to Type I errors; large sample sizes may increase the possibility of rejecting the zero hypotheses (e.g. claiming a change in safety climate occurred when actually it did not) because a high level of statistical power. This possibility has been considered in the interpretation of the results. The sizes of significant differences in safety climate mean scores (between measures) are relatively large in paper 3, thereby decreasing the possibility of Type I errors. In health care (paper 2), five of the safety climate scores were not significantly different between the two measures, as such eliminating the risk of Type I errors for these results. Five safety climate dimensions are still significantly different between measures in health care. Readers should be aware that the change of means is small for the significant changes; therefore, the importance of the significant safety climate changes should not be overestimated when interpreting the results.

[12] Type I error is the error of rejecting the null hypothesis even though the null hypothesis is true. Type II error is the error of accepting the null hypothesis when it is false (Cozby, 1993).

The choice of samples and the development of models in the different studies must be considered in relation to external validity and the generalisation of results. For instance, can the stability of safety climate be generalised to all hospitals? Can modelling of the safety culture programme be valid for all similar types of programmes?

The studies in papers 1 and 2 were conducted in a relatively large regional public hospital offering specialised health care. This setting may limit the generalisation of results to similar types of hospitals. For example, it can perhaps be more difficult to implement improvement efforts relating to safety climate in large hospitals compared to smaller ones, thereby limiting the external validity of study 2. It is also possible that safety climate may be easier to improve at private hospitals, especially if safety climate becomes a competitive issue among hospitals.

Workers attending the first and second measurement in papers 2 and 3 likely differed to some degree, which could be considered a limitation of the study. However, as previously mentioned, respondents' task was not to evaluate personal attributes (e.g., attitudes), but perceptions of safety climate in the social environment. Given that the same social environments (i.e., same workplaces) were evaluated for both measurements, the potential respondent invariance between measures is not considered a large problem. Still, another possible approach would be to identify individual workers and compare only pair wise perceptions of workers identified for both measurement waves[13].

Zohar (2003) suggests that safety climate can only be meaningfully construed at the subunit/group level and the organisational level. Still, a strict aggregation level criterion was not established before the conducted studies. Similarly, by referring to the definition developed by Flin et al. (2006), a strict criterion was not set that safety climate perceptions should be shared. The rationale for this was upheld as safety climate perceptions were not considered to be shared if or when

[13] This may lead to practical and ethical challenges when it comes to securing worker anonymity.

the underlying safety culture was not shared. Previous researchers have acknowledged that organisations' cultural elements may not be shared (e.g., Hale, 2004; Martin, 2002; Richter & Koch, 2004); given the many overlapping and common topics among the climate and culture concepts (Denison, 1996), these considerations were considered plausible. Moreover, it is also interesting that common safety climate dimensions were replicated in two measurement waves assessed among workers in the North Sea (paper 3). This result suggests that safety climate may be monitored at a higher level than the organisational level.

In paper 3, safety climate scores are compared at the sector level for offshore workers on North Sea platforms. Although comparisons at this level are uncommon in the safety climate literature, this approach is justified because a common measurement model is identified in the Norwegian continental shelf samples at two measures. Another approach could also have been used as well; for instance, scores could have been limited to aggregation at the platform level. As such, platforms ranked on safety climate scores could have been compared between measurements. Using this alternative, the relative rank of platforms could have been compared between measurements. However, it is an advantageous and tempting possibility to aggregate safety climate scores at the Norwegian continental shelf level to monitor change over time in regard to risk-related (shelf) variables.

5.2 Trends, models and safety improvements across sectors

Central themes in this thesis focus on ensuring valid measures so that longitudinal trends, structural models and safety improvement efforts can be investigated.

In paper 3, results using MANOVA indicated an overall difference between the two measurements conducted, with an approximately two-year interval, suggesting a general difference and changeability of safety climate. In addition, results using ANOVA demonstrated significant improvement among all safety climate dimensions, with the exception of system comprehension. These results indicate that the safety climate level was relatively unstable from 2001 to 2003 among a large sample of workers on platforms in the North Sea, thereby suggesting that safety climate as a phenomenon is changeable and improvable.

Opposite results were achieved at the hospital, where the safety climate dimensions were relatively stable between the first and second measurement wave two years later. The overall change between the measures was very small when estimated using MANOVA. Further exploration using t-tests indicated that three safety climate dimensions (i.e., supervisor/manager expectations and actions promoting safety, teamwork within hospital units, non-punitive response to error) were improved during the period and two (i.e., organisational management support for patient safety and staffing) were reduced, while five did not significantly change. In addition, small significant improvements in two of the three outcome measures were observed in regard to patient safety grade and stop working in dangerous situations. The results indicate that the level and content of improvement efforts were not sufficient to generate greater changes regarding safety climate and outcomes at the hospital.

The large safety climate change among offshore personnel may have different possible interpretations. One interpretation is that the change is related to the outer levels of safety culture; hence, that change is not related to deeper levels (e.g. related to basic assumptions). Such an interpretation is based on the assumption that it takes a longer period of time to change basic assumptions and more deeply rooted attitudes, and that the safety climate change observed should be interpreted as a more superficial change related to safety culture. Another possible interpretation is that safety climate is more extensively coupled to deeper levels of safety culture and culture in general, which can explain why the safety climate remained relatively stable at the hospital in paper 2. This approach raises another explanation for the relatively large safety climate improvement that paper 3 indicated; as safety climate reflects and is rooted in the safety culture phenomena, this large change in safety climate also indicates that the safety culture has been improved during the period.

In any case, the results in papers 2 and 3 are contradictory as they indicate that safety climate is both relatively stable and changeable/improvable during a two-year period. The explanation for this contradictory finding may relate to the different contexts in which these studies were conducted. Stable results with regard to safety climate can reflect different stability issues related to the health care setting in general. Such aspects can relate to how the hospital is organised as well as stable hospital surroundings and how the Norwegian health care system is organised. Neither the hospital structure nor the health care system suffered from major reforms or changes between the first and second measurement. The stabile safety climate level can also relate to other cultural factors (e.g., professional cultural barriers in health care that may hinder change) (Amalberti et al., 2005).

High oil prices and a positive drive in the oil industry may also be possible explanations for the positive development of safety climate from the first to the second measurement in paper 3. This drive may have positively influenced the prioritisation of safety in the sector and on the platforms. Nonetheless, the results indicate that the level of safety climate at the hospital is relatively stable and that more comprehensive interventions are necessary to more extensively improve the safety climate level in hospital settings.

Differences between the industries are probably related to the different safety traditions within the two sectors. The petroleum industry has generally strived to improve safety over the last decades (Haukelid, 2008). The drive for improved patient safety in modern health did not get an awakening in the United States until the book *To err is human* was published in 1999 (Institute of Medicine). Another explanation is that the risk in many subgroups in the petroleum industry involves direct risk for the worker (e.g., if a platform explodes), while the perceived risk of health care workers in general may be lower compared to offshore petroleum personnel. This may result in a lower personal interest and motivation for improving safety among health care workers.

Some lessons may also be learned from paper 5 in regard to improving safety in other contexts (e.g., health care). The petroleum company under study in paper 4 is the same as the petroleum company in paper 5, implementing a comprehensive safety programme. This petroleum company has for many years strived to improve its safety culture and safety behaviour through the implementation of safety improvement efforts. Therefore, it is not surprising that the level of safety climate and safety behaviour is lower in the health care organisation.

The starting point for the safety programme stemmed from central stakeholders' desire to improve safety in the organisation. Thus, a long-term safety programme was developed and implemented in such a way that employees had no doubt that improvement efforts were initiated and that safety concerns should be taken seriously at all organisational levels. The implementation of a high-cost programme symbolises that safety is important, which probably also had a symbolic importance in addition to the implementation of actual interventions. However, health care systems do not have the same resources available to spend on large programmes as the petroleum does, thereby reducing the potential symbolic benefits of implementing such programmes. An explanation for the small improvements discovered in health care could be that the level of improvement efforts was generally weak during the period between measurements, which explains the relatively stable level of safety climate at the hospital.

To increase the potential for organisational improvement efforts in health care, change initiatives need to be thoroughly anchored at all organisational levels. To ensure this, it may be beneficial to define and implement a safety programme[14]. In this way, hospital management also approves the importance of safety, which is an important aspect during safety improvement efforts.

Another point in paper 5 is that the primary aim of the model development was not to generalise results to other types of programmes. However, some issues can probably be generalised,

[14] This may be important even though the programme potentially has a low budget.

especially those regarding the significance of a thorough implementation of safety programme interventions. It is logical that the importance of satisfaction regarding programme implementations, leadership involvement, and degree of programme activities can be generalised to other kinds of safety programmes. The same point can be made regarding the importance of personal programme commitment when implementing safety programmes.

The structural model developed and assessed in paper 4 may also be of relevance in the development of improvement efforts. The model clearly illustrates the importance of five climate variables to the level of safety behaviour. The support for the model in both health care and offshore petroleum settings underscores the importance of the safety climate variables included in the model when implementing efforts to improve safety behaviour. The path estimates in the modelling of safety climate suggest it is especially important to include leaders and managers when conducting safety interventions. Still, given that the other components in the structural model also influence safety behaviour, the results further indicate that improvement efforts should aim to improve the other three components included in the model—namely, 1) teamwork within units, 2) learning, feedback, and improvement within units, and 3) transitions and teamwork across units.

Another general assumption in paper 4 was that safety climate variables at the unit level would mediate the effects of supervisor expectations and actions promoting safety (at the unit level) as well as the effects of the other organisational-level dimensions. Although this assumption is generally supported, it is also possible to assume that organisational-level dimensions can have a direct influence on safety behaviour; however, this theoretical possibility was not specified in the model assessment. Nevertheless—and as suggested by Flin (2007)—results indicate that the dynamics of safety climate in health care may not be particularly distinctive compared to other industries. Still, the same model did not fit onshore petroleum workers; one can only speculate why the model did not fit with this group. Onshore petroleum workers have a large share of administrative work characteristics and may differ from offshore petroleum and health care workers in this manner.

Therefore, other dynamics may better explain the relation between organisational factors (including safety climate) and safety behaviour among onshore petroleum workers.

6 Concluding comments

6.1 Limitations

A successful piece of research doesn't conclusively settle an issue, it just makes some theoretical proposition more likely (Cohen, 1990, p. 1311).

Although validity and reliability concerns have been stressed in this thesis, some limitations of the research need to be addressed. The safety climate dimensions assessed in the thesis have only been correlated with non-questionnaire data in paper 3, using accident statistics. One obvious limitation of the other papers in which safety climate was assessed is that criterion measures are limited to a common method involving the use of the same questionnaire and method. However, paper 3 illustrates the problem that may arise when using accident statistics: the low correlations with accidents may be due to measurement error[15] issues related to measurement of accidents. Still, validating safety climate scores with other outcomes is important for ensuring criterion validity. As such, this is a limitation of papers 1, 2, and 4.

To some degree the same limitations are relevant in paper 5, in which it would have been interesting to compare scores of measurement concepts with trends on safety statistics before, during, and after programme implementation. In paper 5, this limitation is taken into consideration through the combination of methods that increase the support for the measurement and structural models being developed. However, this does not eliminate the fact that the structural model developed is assessed on cross-sectional data that reduce the causal evidence of the model. This point is also relevant with regard to paper

[15] Naturally measurement error is also relevant in the measurement of safety climate.

4. However, exploring and assessing structures between concepts are important issues in the development of theories and validation of constructs. Therefore, the structural model assessed in paper 4 hopefully contributes to the understanding of structural relations among safety climate dimensions. However, the theoretical background for the structural model developed and validated in paper 4 needs to be further elaborated within the framework of relevant safety theory.

Paper 5 presents examples related to the dynamics of improving safety culture. Based on the extensive overlapping between safety culture and safety climate, it is reasonable to believe that many of the principle findings from paper 5 are also applicable to the improvement of safety climate. Yet one possible approach in papers 2 and 3 would have been to take a closer look at improvement efforts during the measurement periods. The common research design used in papers 2 and 3 did not contribute much insight into the dynamics of change processes with regard to safety climate. Nevertheless, the structural model assessed in paper 4 resulted in certain suggestions regarding how safety climate dimensions are structurally interrelated. Basically, paper 4 supports a link between higher and lower level safety climate factors and safety behaviour, which is the general principle behind development of the structural model assessed in paper 4.

Some limitations should also be considered regarding model generalisation of the safety culture programme under study. Other types of programmes will potentially illuminate other mechanisms, such as those related to conditioning behaviours if the programme under study was solely based on a behaviour-based approach. It is also worth mentioning that the model development in paper 5 is largely based on an inductive approach, benefiting from the combination of methods used.

The final models developed in paper 4 and 5 should be considered as “methodologies in the making” and not as completed research fields. Other research designs or measurement instruments would have emphasised additional types of dynamics or model components other than the approach used in this study.

The health care industry is only represented by one hospital in the thesis. However, this hospital is a large regional hospital with a wide range of services and is in many ways representative of large public hospitals in the Norwegian health care system, but not necessary smaller private hospitals. Paper 4 is also limited in that it only studies one petroleum company.

6.2 Implications

Research findings in this thesis generally support the use of four different instruments in the assessment of safety climate. HSOPSC and HSOPSC-short are suitable for the assessment of safety climate in health care, while NORSCI and SSCI are suitable for the assessment of safety climate in petroleum settings. The fact that measurement concepts can be validated across samples is an important criterion for both practitioners and the theoretical development of a research field. To improve the understanding of the safety climate field, researchers should continue looking into the psychometric properties of the instruments explored in this thesis.

Studies on longitudinal change indicate that the safety climate level at a Norwegian hospital is relatively stable when investigated over a two year period. Results further indicate that the safety climate level in health is lower than in petroleum. These results indicate both a need to improve the safety climate in health care and the need for comprehensive efforts to achieve this.

Additional research will be needed to gain insight into mechanisms that mediate or moderate improvement efforts of safety climate and safety culture in different settings. As such, structural model development and assessment may be a beneficial approach for use, maybe also in combination with other methods. Generally, future research should further refine safety explanatory models that are applicable to both specific and general settings. These models may, for instance, be related to the dynamics of organisations in general or more specific improvement efforts related to safety during a limited period of time.

Results in this thesis suggest that improvement efforts should aim to develop worker commitment to safety interventions and underscores the importance of a comprehensive implementation of safety activities to increase the likelihood of cultural and behavioural effects concerning safety. Such efforts can be explained theoretically, but are hard and complicated to implement in practice.

6.3 Conclusions

This thesis has contributed to the understanding of psychometric properties of four safety climate instruments: 1) HSOPSC, 2) HSOSPC-short, 3) SSCI, and 4) NORSCI. The empirical support and evidence of HSOSPSC is larger than the other instruments used since the factoral model of HSOPSC is replicated across cultures. However, studies conducted in this thesis indicate that the psychometrics qualities of HSOSPSC-short, SSCI and NORSCI are generally satisfactory.

No simple answer exists regarding how safety climate and safety culture should be improved. Cautions should be made by simply and uncritically copying solutions from other high hazard industries and implementing them in health care. The results in paper 3 suggest that the safety climate level can be considerably improved in two years and that safety climate is noting more than relatively enduring as suggested by Moran and Wolkwien (1992). The study that was conducted in a large public hospital with specialised health care indicated the opposite—namely, that the safety climate level is highly enduring. This result in paper 2 is probably related to the level of improvement efforts and other unique characteristics associated with the health care organisation under study. Yet the stability of safety climate still, to some degree, contradicts the assumption made by Moran and Wolkwein (1992) that safety climate compared to safety culture is less endurable.

The model assessment in paper 4 supports the possibility of a common safety climate model in health care and among offshore petroleum workers in the North Sea. Generally, this finding supports Flin's (2007) assumption that the dynamics of safety climate models applied in other industries may be more similar to health care settings than previously assumed.

The study in paper 5 developed and validated a structural model, illustrating the dynamics and effects of the safety culture programme. This study demonstrated the significance of developing worker commitment to programme implementation and the importance of a comprehensive implementation of programme activities to increase the likelihood of cultural and behavioural changes concerning safety.

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