The Role of Safety Climate and Exposure to Environmental Hazards on Occupational Illness

By

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Abstract

The Role of Safety Climate and Work Hazards in Experiencing Occupational Illness

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Abstract: This study investigated the relationship between workplace hazards and safety climate and their effect on occupational illness using data from the 2007 Trends in Risk Level questionnaire. Study 1 outlines the history of research into the offshore oil industry in the North Sea, the PSA questionnaire, and presents a process for refining the safety climate measure in the PSA questionnaire. Study 2 took the safety climate scale, along with the exposure to environmental hazard scale, to predict occupational illness. I conducted exploratory factor analyses on the safety climate scale and occupational illness scale. I reported a five factor solution that accounted for 53.9% of the variance. The five factors were: Accident prevention, Threats to safety, Competence, Chemical Knowledge, and Training. Hierarchical regression analysis showed support for the hypothesis that both safety climate explains unique variance in occupational illness beyond what is explained by exposure to hazards.

The Role of Safety Climate and Work Hazards in Experiencing Occupational Illness

The past two decades have seen organizations become more aware that technology and hardware problems alone are not responsible for accidents and disasters on industrial sites (Flin et al., 2000). Investigations into several high profile industrial disasters led to the realization that social and organizational factors play an important role in the occurrence of disasters and accidents (Mearns et al., 2003). The recognition of the role of social and organizational factors in accidents and disasters led to the study of High Reliability Organizations (Wiegmann, 2004). A high reliability/high risk organization is one where complex human and technical systems interact on multiple levels, and where the failure of either system can result in catastrophic damage to infrastructure and people (Reason, 1990). Military (particularly air craft carriers), nuclear, chemical, and aviation are frequently cited as examples of HROs. These industries are notable not because they are accident free, but that these accidents and errors do not cripple the operation of the organization This is accomplished not through strict hierarchical style management, but by decentralizing decision making and allowing employees with the most expertise in a given situation, regardless of rank or position within the company, to deal accordingly with the problem (Wiegmann, 2004).

One of the most important examples of an investigation into the organizational and social factors in a major industrial disaster was the investigation into the meltdown of the #4 reactor of the nuclear power generator at Chernobyl in 1986 (Cox & Flin, 1998).

Due to human error, a reactor exploded, throwing radioactive material into the atmosphere. Following the accident, the OECD Nuclear Agency prepared a report discussing the conditions that led to the disaster. Essentially, the report concluded that the accident occurred due to a 'poor safety culture' that led to workers not performing their duties to the best of their abilities, which resulted in the meltdown of the #4 reactor (Mearns & Flin, 1999). This led to an increase in the amount of research into the contributions of organizational and social factors as they relate to safety.

The investigation into the Chernobyl disaster was the first high profile investigation into the impact of social and organizational factors in an organizational disaster. However, the investigation of social factors in organizational safety date back to the early 1950's, with a study of automobile plant workers (Guldenmund, 2000). This early study of safety climate would pre-date the earliest modern investigation of safety climate by nearly 30 years. The study of modern safety climate, often defined as worker's perceptions of the relative importance placed on safety by management (Zohar, 1980), began with a study of employee perceptions in a variety of industrial sites (Zohar, 1980). The results of the study led to a number of conclusions. The first is that employee perceptions of climate changes according to the level of risk and hazard exposure within their industry. Workers in industries with low levels of hazard (food processing plants in this study) have lower perceived climate scores than do higher hazard industries (chemical plants). Second, the most important dimensions of climate were perceptions about management attitudes to safety and perceptions of the relevant importance of safety in general production issues. The last conclusion was that safety climate is a useful tool in predicting occupational behavior (Zohar, 1980).

Safety climate is thought to affect the occupational behaviors of workers through a two stage process (Zohar, 2000). Upper level management creates policies and procedures surrounding safety and other general production issues and this information is then passed on to workers in the form of specific instruction and directives delivered through supervisory practices (Zohar, 2000). For example, the purchase of safety equipment would be organizational level safety. The implementation and monitoring of the use of the equipment would be supervisory level safety. Organizational priority can have a direct effect on worker behavior. For example, if organizational policies (whether explicit or implied) favour production over safety, workers will infer that production is valued and will disregard safety (Zohar, 2000). In this case, safety has a low relative perceived priority compared to production.

Safety climate perceptions inform desired role behavior for workers because they provide information about the way that organization wants workers to behave based on the relative importance of safety versus other competing goals (Zohar, 2000). This should result in a positive correlation between perceptions of climate and employee behavior (Zohar, 2000).

One way in which this mechanism appears to operate is the behavior-reward expectancy relationship. Workers should expect to be rewarded for conforming to behaviors that are given the most priority by the organization (e.g. safety or production).

Outcomes are a major regulator of behavior in that social constraints place barriers on people's behavior to behave in an optimal way (Bandura, 1986). In a general sense, behaviors that are mutually judged to offer the best chance at gain are the ones that will be adopted. If risky behavior is judged to be the best way to achieve an outcome, then it will be adopted by the individuals in that social context (Bandura, 1986).

In a safety context, perceptions of the relative importance of safety will influence the way that workers behave. The perceived importance of organizational commitment to safety, or lack thereof, is an important determinant of behavior because it affects worker motivation (Zohar, 2000).

A key consideration of the above safety climate research is that safety behavior is the way in which perceptions of safety climate manifest in workers. However, this relationship is often implicit, with safety behavior never actually being measured (Neal & Griffin, 2000). Safety performance is made up of determinants and components. Determinants of safety performance are knowledge of safety, work skill, and motivation to work safely. Components of safety performance are safety task performance and contextual safety performance (Neal & Griffin, 2000). Climate influences safety motivation and knowledge, which in turn feeds safety participation and compliance (Neal & Griffin, 2000). Safety participation refers to behaviors that do not directly relate to a worker's personal safety but rather provide a general supportive atmosphere for safety. Safety compliance refers to the core activities that workers need to carry out to maintain workplace safety (Neal & Griffin, 2000).

Low levels of safety performance can be linked to higher levels of accidents and injuries in the workplace (Neal & Griffin, 2006). An individual's failure to comply with safety practices or participate in wider safety initiatives can either impact the individual directly through the experience of an accident or impact the coworkers by creating dangerous situations (Neal & Griffin, 2006). Given the link between safety climate and performance, it is not surprising that one of the typical outcomes used as a measure of levels of climate is accidents (e.g. Hofman & Setzer, 1996; Zohar, 2000; Mearns et. al, 2003a; Wallace et al., 2006). These are usually measured as the rate of accidents divided by a pre-determined number of hours worked (Shannon et al., 1997). These models typically use safety climate as an antecedent to acute injuries due to workplace accidents (e.g. Mearns et al., 2001a; Barling, 2002; Zohar, 2002; Kelloway et al., 2006). One factor that has not received much attention in the prediction of accidents and injuries in relation to safety climate, however, is exposure to environmental hazards.

Safety Climate and Environmental Hazards

There has been little work done concerning the relationship between exposure to workplace hazards and safety climate. In his initial work on developing the construct of safety climate, Zohar (1980) reported results of safety climate surveys in terms of the inherent danger associated with various industries, finding that more dangerous industries generally had a higher perceived climate of safety. The relationship between hazards and safety climate was essentially ignored until Smith et al. (2006) built on Zohar's research by examining the relationship between safety climate and injury risk while controlling for industry sector specific accident rates. One of the methodologies used was to control for inter-industry differences in risk. The researchers used industry wide injury rates as a control. The rationale behind this method of control stemmed from previous research that found that many originally significant effects on injuries (e.g. decision latitude, social support) were reduced to non-significance when job differences were controlled for, suggesting that inherent job characteristics are responsible for differences in injury rates rather than safety climate. When inter-industry differences in risk were controlled for the influence of safety climate on injury risk was reduced to non-significance.

Neither of these studies, however, used accidents or occupational illness as an outcome variable. Zohar correlated climate with hazards, while Smith et al. used risk of injury rather than injury itself. Despite this, some predictions can be made as to the nature of this relationship. Zohar's (1980) study shows a positive relationship between hazards and safety climate. The cause of this was not speculated, but it is possible that preventative measures taken by management in high hazard industries to protect their workers lead to a perception that safety is a priority at that work place. The opposite may hold true for companies with low hazards and lower perceived safety climate (Zohar, 1980). If the inherent danger is low, management does not need to take action, creating a low level of perceived safety climate. This would indicate a positive relationship between hazards and perceived climate.

A different study showed contradictory findings to the positive relationship between safety climate and industry hazards. A sample of workers on the Norwegian Continental Shelf showed that climate perceptions were significantly, negatively correlated to workplace hazards (Mearns et al., 1997). The same study found similar relationships in a sample of oil workers in the UK sector of the North Sea. An interesting relationship can be seen if these results are considered together. Across industries with a range of hazards, perceptions of safety climate show a positive relationship to exposure to hazards. However, within specific industries negative relationships between perceptions of safety climate and exposure to hazards can be found. It becomes apparent that safety climate alone does not suffice when making predictions about workplace health-related events. Exposure to environmental hazards must also be considered alongside safety climate. Including exposure alongside climate often reduces the impact of safety climate and gives a more complete prediction about health related events like accidents (Smith et al., 2006).

An excellent area in which to study the relationship between safety climate, exposure to hazards and occupational illness is the offshore oil industry. Offshore oil workers are often exposed to poor environmental conditions like chemical hazards, physical hazards, biological hazards, ergonomic hazards, and psychological hazards (Gardner, 2003). The offshore oil industry is also a leader in safety systems, with large governing bodies that oversee oil production legislation and licensure. One of the largest concentrations of offshore oil installations is the North Sea. This area (particularly the UK and Norwegian sectors) has received a large amount of attention in terms of academic research into factors that lead to accidents and injuries at work.

The current study builds on this research by using existing data collected by the body in charge of collecting health and safety related data in the Norwegian sector of the North Sea. The Petroleum Safety Authority (PSA) of Norway provided a questionnaire and data from 2007 that asked offshore oil workers about their perceptions about safety climate, their exposure to hazards, and health outcomes associated with work. Study 1 outlines the history of research into the offshore oil industry in the North Sea, highlights issues with the PSA questionnaire, and presents a process for refining the safety climate measure in the PSA questionnaire. Study 2 builds on Study 1 by taking the refined safety climate scale and using it, along with the exposure to environmental hazard scale, to predict health outcomes.

Study 1

The Norwegian continental shelf (NCS) has been a fertile source of oil for the last 70 years, with petroleum company BP discovering oil in the area in 1938. Low level exploration continued for several decades, with the first commercial license for oil exploration awarded in 1965, followed by the first well drilled the following year (Norwegian Petroleum Directorate, 2010). Today, the oil industry on the NCS employs over 80,000 people in a variety of occupations (Gardner, 2003). In 1972 the Norwegian Petroleum Directorate (NPD) was created to manage licensure and regulation of offshore drilling on the NCS. This body was responsible for both safety and operation of oil drilling operations until 2004, at which time the safety arm of the NPD split off to form the Petroleum Safety Authority (PSA) (Norwegian Petroleum Directorate, 2010). Managing the safety of such a large workforce is a daunting task, but the authority in charge of Health and Safety, the Petroleum Safety Authority (PSA), has done an admirable job at reducing both major incidents and personal injuries. There has not been a major accident for over 20 years and individual occupational incidents have also been in decline (Rundmo et. al, 1998). As a result of both the hazardous environmental conditions present in the North Sea and the efforts of both the NPD and PSA to reduce accidents and injuries, the NCS has been a source of interest for academic researchers studying risk perception and health and safety.

Previous Research on the North Sea Offshore Oil Industry

One of the earliest employee perception studies in the North Sea was conducted in 1980. It was a study of the risk perception of workers on Statfjord A, a platform owned by Mobil. Participants were asked how safe they felt about a variety of risks like flying in a helicopter or fire (Mearns & Flin, 1995). Another series of employee perception studies examined risk, environmental conditions, and social and organizational aspects as they relate to health and safety on the NCS (Marek et al., 1985a; Marek et al., 1985b; Marek et al., 1987; as cited in Rundmo, 1992b). Cognitive strategies like affective evaluation of probability were considered to be important factors in risk perception. A separate literature review of health and safety concerns in ocean-going industries (fishing and offshore oil) recommended that more research be conducted into the relationship between job stress, risk perception, and occupational accidents in offshore industries (Sutherland & Flin, 1989, as cited in Rundmo, 1992b). This, in part, led to a series of studies investigating risk perception in the NCS oil industry.

One study examined perception of risk, job stress, accidents, and management and employee commitment. The study surveyed a sample of Norwegian offshore oil workers by collecting non-matched data in 1990 and 1994 (Rundmo, 1992a, 1992b, 1994a, 1994b). The general conclusion was that participants perceived working in the offshore oil industry as less risky in 1994 than did participants surveyed in 1990 (Rundmo, 1996). The conclusion was that this was due to a combination of improved organizational approaches to safety and less media coverage of the Piper Alpha disaster in 1990 than in 1994. An explosion on the Piper Alpha rig in 1988 caused the death of 167 people.

The Piper Alpha disaster was the largest disaster in the UK sector of the North Sea. A public inquiry into the cause of the accident found the immediate cause to be deficient maintenance. The inquiry not only highlighted the acute cause of the disaster, but also the organizational deficiencies that contributed to the conditions leading up to the explosion. Lord Cullen's public inquiry stated that organizational, training, and legislational inadequacies in the managerial and regulatory systems contributed to the disaster (Mearns & Flin, 1995).

The Norwegian risk perception survey was adapted using a sample of offshore oil workers in the UK sector of the North Sea using a translated version of the Norwegian questionnaire. (Flin et al., 1996). Participants were surveyed on a wide variety of topics, including: demographic details, current job situation, physical working environment, perception of risks – hazards, probability of injury, job satisfaction, safety facilities, other's concern for safety, safety attitudes, occupational health, platform safety, accidents, personal accidents and near-misses and personal support and health from others (Flin et al., 1996). The employees surveyed generally felt safe from major hazards and while completing their work tasks.

A cross cultural study examined UK and Norwegian employees' perceptions of safety systems employed by the organizations they work for, employee and management commitment to safety, workload and job stress. (Mearns et al., 2004). Nationality and installation were responsible for differences in how respondents rated organizational and social factors. These areas are considered to be a good representation of overall safety on an offshore platform (Mearns & Flin, 1995). Conclusions made in part from the report into the Piper Alpha disaster highlighted three areas that could be studied further. They are: knowledge, situational awareness, and organizational culture. Knowledge refers to perceptions of hazards and the control of those hazards. Situational awareness refers to perceptions of the work environment and how that affects decision making. Finally, organizational culture refers to safety culture and the commitment of fellow workers and management to safety (Mearns & Flin, 1995). This conclusion is similar to the conclusions made following the Chernobyl incident that social and organizational factors play a role in major disasters (Mearns et al., 2003). These three tenets guided the future of research in the NCS and UK sector of the North Sea and signalled a move away from a focus on risk perception to the study of safety climate.

An ongoing research project conducted by the regulatory body of the Norwegian offshore oil industry has built upon much of the research presented here to develop a tool designed to capture the safety environment experienced by offshore oil workers on the NCS, including safety climate, exposure to hazards, and occupational health.

Trends in Risk Level Questionnaire

In 2001 the Norwegian Petroleum Directorate (NPD) began tracking Health, Safety, & Environment indicators. This project was entitled Trends in Risk Level (TRL). The goals of the TRL project were threefold: to evaluate the effectiveness of current Health and Safety initiatives, identify important areas for future Health, Safety, & Environment interventions, and to provide in-depth information on accidents and near misses (Tharaldsen, 2008; Petroleum Safety Authority, 2010). The term Health, Safety, & Environment originated in a 2002 report by the PSA that states: ''In order to make it clear that this section applies across the entire scope of application of the regulations, the expression ''health, environment and safety culture" is used instead of the more established term ''safety culture." HSE builds on the traditional idea of Health and Safety as a means of accident prevention to include the impact of environmental hazards on occupational health. The PSA envisioned occupational health problems to be those that are caused by long term exposure to hazardous workplace conditions and are often diagnosed outside of work or after someone stops working (Hoivik, 2009b).

One aspect of the TRL project is designed to measure the full scope of health, safety, and environment. A bi-annual survey of on the NCS entitled 'Trends in Risk Level on the Norwegian Shelf Questionnaire' is an extensive questionnaire that combines safety climate, quality of life, risk perception, and occupational illness items, along with detailed demographic information, to get a picture of workers' perceptions of HSE in the offshore oil industry in Norway. Many of the scales in the questionnaire, specifically those in the climate and risk perception subscales, draw heavily on the previous research conducted in the NCS and UK sector of the offshore.

There have been five bi-annual surveys conducted since the project's inception (2001, 2003, 2005, 2007, and 2009). The PSA uses the results of the survey in conjunction with yearly reports on risk levels using other indicators to obtain a broader picture of risk and safety than can be achieved through the survey alone. The current study will use data from the 2007 version of the questionnaire. There have been several other studies using previous versions of the TRL questionnaire for academic research.

Previous Research Using the TRL Questionnaire

Since the inception of the TRL questionnaire, at least three studies have been published using data from different years of the study. Tharaldsen et al. (2008) examined the 2001 and 2003 versions of the questionnaire. A five factor model of safety climate was proposed for the 32 item 2001 questionnaire and was replicated using the 2003 questionnaire. The five factors reported in this model were Safety Prioritization, Safety Management and Involvement, Safety Versus Production, Individual Motivation, and System Comprehension. Installation and company predicted reported levels of safety climate. Hoivik et al. (2009a) performed a similar factor analysis on the 2005 version of the scale (see Appendix E for complete factor structure). This study proposed the same five factors as the previous study with the addition of a sixth factor, Competence. This study also concluded that installation explained more of the variance in safety climate than any other variable.

One issue with the factor structures proposed in these studies is that the item groupings do not make conceptual sense as factors. For example, the items 'Lack of maintenance has resulted in reduced safety' and 'Reports on accidents or dangerous situations are often 'smartened up'' both load on a factor labelled *Safety Versus Production* (Hoivik, 2009a). These items should theoretically load better on other factors such as *Safety Prioritization.* For the current study, a process was designed to obtain a more coherent factor structure from the available items by sorting them based on existing safety climate frameworks.

The safety climate scale in the 2007 version TRL questionnaire contains 56 items covering a wide variety of safety climate topics (see Appendix A for complete TRL questionnaire). Some items were taken directly from previous research into the offshore oil industry. Others were adapted and updated from the same body of research. Others still appear to have been created specifically for the purposes of the TRL research project.

Many of the items used in the 2007 TRL questionnaire are drawn from previous research into the offshore oil industry in Norway and the UK sector of the North Sea in the early 1990's. As only some of this research details with safety climate, items may be included that do not measure safety climate constructs. Examples of some items that do are: 'The tasks I carry out have been carefully planned out by others,' 'My immediate supervisor asks me for my advice before making their decisions,' 'Use of personal safety equipment,' and 'Orderliness and cleanliness of the place of work (Rundmo, 1992a).' A paper measuring commitment and attitudes to safety in the same population of oil workers included items like 'Sometimes it is necessary to take risks to get a job done,' and 'Calling attention to breaches of safety can easily be felt as an unnecessary hassle (Rundmo, 1994a).' However, some items in the current study do not fit with currently published safety climate research (Flin et al., 2000). An example is: 'I feel sufficiently rested when I am at work'. Being well rested at work, while possibly having an impact on safety, does not conform to a typical safety climate definition that deals with worker's perceptions of the relative importance of safety in comparison to competing goals (Zohar, 1980).

A second issue is that the items are worded in two different levels. Items like 'The safety delegates do a good job,' and 'Risk-filled operations are always carefully planned before they are begun,' represent perceptions of higher level organizational processes on the installation. Items like 'I can influence matters in my workplace,' and 'I would rather not discuss HSE matters with my immediate supervisor' operate on a much more specific individual level. Combining 'I' statements with judgements about others can create some ambiguity over exactly what participants are being asked about. In this example it is difficult to determine if the participant is responding about their attitudes or their supervisor's attitude towards communication. It also creates issues when attempting to analyze the factor structure of the scale.

Previous papers reported factor structures that were derived purely through empirical factor analyses (e.g. Theraldsen, 2008 & Hoivik, 2009a). As mentioned above, the reported structures did not reflect common safety climate constructs. A more theory driven, qualitative approach was devised for the current study to determine if the items in the TRL safety climate subscale conform to common safety climate concepts.

Method

Sorting

Two subject matter experts (SMEs) with extensive experience in safety climate concepts were asked to sort the 56 climate items into factors. One SME was recently awarded her PhD in Industrial/Organizational Psychology from Saint Mary's University. Her doctoral research investigated the antecedents of safety and safety climate. The other SME is a PhD candidate at Saint Mary's University who has conducted original research in areas of patient safety and safety motivation and is well versed in the safety climate literature. I decided to use an existing theoretical safety climate framework to help place the items in a recognizable format. In deciding what framework to use as a basis for sorting, I thought that choosing any one researcher's framework (e.g. Zohar, Cheyne) would be too restrictive, as the items in the current survey reflect a variety of safety climate concepts. Therefore, I decided that examining existing review articles would provide the best framework. There are two main safety climate review articles (Guldenmund, 2000; Flin et al., 2000). The first article reported on the wide range of factors found in safety climate research. The number of factors reported ranges from two to 19. Although this article was useful in offering a picture of the scope of safety climate research, it did not offer a clear cut framework by which to sort the safety climate items being used in the current study because it did not synthesize the literature and merely summarized it. The second review article was more amenable to the sorting task (Flin et al., 2000). It reviewed safety climate literature and identified six themes that covered the most commonly studied areas of safety climate. This approach suited the goal of having a well defined framework by which the climate items could be sorted. This article was also preferable as its authors worked on many of the studies that became the basis for the TRL questionnaire.

Sorting Themes

Six themes have been identified as comprising the majority of the safety climate literature (Flin et al., 2000). The themes are: management/supervision, safety systems, risk, work pressure, rules and procedures, and competence. Work pressure is often considered within the context of management and supervision in the literature. The review stated that work pressure was often included in safety climate factors dealing with manager and supervisor commitment to safety and was only isolated in a small number of studies (Flin et al., 2000). As a result these themes were collapsed for the purpose of the sorting task. The definition of the risk theme in the article included risk perception and risky behavior. Since risk perception is not covered by the TRL safety climate scale this theme was not included. After folding work pressure into management/supervision and discarding the risk perception theme, four themes remained. They are: management/supervision, safety systems, rules and procedures, and competence. There were also several items on the TRL safety climate survey dealing with personal safety behaviors. I initially proposed that these items would be used to create a safety behavior scale for further research. As such, these items were isolated from the safety climate scale, as safety behavior is a construct separate from safety climate (Griffin & Neal, 2000). To facilitate this separation, I decided to include a theme that encompassed safety behavior and risk-taking behavior. Components of safety behavior that are relevant to the items contained in the TRL questionnaire have been defined as individual compliance with safety procedures and individual participation in safety activities (Griffin & Neal, 2000). Thus, the five factors that will be used in the sorting task are: Management/Supervision, Safety Systems, Rules and Procedures, Competence, and Safety Performance. These five themes encompass a wide range of safety climate ideas as well as safety behavior, which is the proposed mechanism through which safety climate influences behavior (Zohar, 1980).

Sorting Task

Two SME's were presented with definitions and examples for each of the five themes used for sorting, along with an option for 'ambiguous' items that either did not correspond to one of the themes or were ambiguous or poorly worded. They were provided with each item from the TRL safety climate survey typed on an individual piece of paper. They were then instructed to sort the items into the theme they thought it fit with best, based on the titles of the themes and their definitions. If an item fit in more than one category and/or a consensus could not be reached as to the intended target of the item (e.g. a double barrelled item) it was filed into the 'ambiguous' category. The goal of the sorting task was to remove items that did not conform to the safety climate constructs used in the sorting task or were psychometrically unsound.

Results

The two SME's sorted each item into one of the categories discussed above (See Appendix B for complete sorting results). Items that did not elicit agreement when sorted were discarded from further analysis. Five items were sorted into Management/Supervision, nine items were sorted into Competence, five items were sorted into Safety Performance, six items were sorted into Safety Systems, and two items were sorted into Rules and Procedures Interestingly, both SME's independently created a sixth factor, which they labelled Communication of Information. Five items were sorted into this category. Eight items were agreed upon as belonging in the Ambiguous category.

Initially the SME's sorted the items independently. After the SME's sorted the items they felt fit well into their respective categories they had a discussion around the items that they were unsure about. If the two SME's reached an agreement on these 'leftover' items they were sorted into the proper category. If an agreement still could not be reached the item was sorted into the 'Ambiguous' category. From the initial pool of 56 items, the SME's agreed upon a category for 40 of the items and did not reach agreement on 16. This equates to a 71% agreement rate. Of the 40 items that were agreed upon, eight items were sorted into the 'Ambiguous' category and were removed. The five items that were sorted in Safety Performance were removed as well, as safety performance is a separate construct from safety climate. This reduced the total number of items in the revised safety climate scale to 27.

Discussion

This qualitative sorting study was designed to improve the validity of analyses performed using the safety climate scale in Study 2 by removing items that do not reflect common safety climate themes. By removing items that do not match what is commonly defined as safety climate, or are psychometrically poor, the number of items that comprised the scale was reduced from 56 to 27. These 27 items will form the basis for Study 2, which will investigate the factor structure of the scale and examine the role of safety climate in predicting occupational illness. Note that the items in the revised climate scale do not match with items contained within previously reported climate structures from studies based on the TRL questionnaire (Theraldsen, 2008; Hoivik, 2009). This is not a surprise, however as the items that comprise both scales are quite different as a result of the sorting task.

Study 2

As previously discussed, the concept of safety climate was first used to describe the safety environment a study of an automobile plant in the 1950's (Guldenmund, 2000). The North Sea offshore oil industry is a popular topic for safety climate researchers, due in part to the industry's high hazard environment and participating organization's high level of commitment to safety systems.

One of the first pieces of research to study safety climate in the North Sea examined the relationship between typical safety climate constructs (e.g. attitudes to safety, perceptions of production pressure), unsafe behaviors, and accident involvement (Mearns et al., 2001a). The paper concluded that, among other things, occupational hazards account for the most injuries experienced in the North Sea and that the likelihood of these hazards being realized is controlled by the perceived efficacy of safety measures

(Mearns et al., 2001a). Another paper measured six facets of safety climate: satisfaction with safety activities, perceived supervisor competence, perceived management commitment to safety, willingness to report incidents, frequency of general unsafe behavior, and frequency of unsafe behavior under incentives (Mearns et al., 2001b). One conclusion was that safety climate varied across platforms and was not consistent over time (Mearns et al., 2001b). Another was that the perceived commitment of managers to safety was important in predicting safety behaviors and satisfaction with safety systems.

Supervisor and manager commitment and involvement in safety is a major component of safety climate, but is typically measured through worker's perceptions (Flin et al., 2000). A study of offshore oil installation managers questioned the OIMs on six elements of safety climate: health and safety policy, organising for health and safety, management commitment, workforce involvement, health promotion and surveillance, and health and safety auditing (Mearns et al, 2003). One major conclusion was that the experience of an accident was associated with less satisfaction with safety systems. Other conclusions were that workers who had previously been involved in an accident had reported a lower level of involvement in safety activities, more work pressure, and less favourable general behavior (Mearns et al, 2003). Finally, workers on UK and Norwegian offshore oil installations were compared on six scales: risk perception, satisfaction with safety measures, perceptions of the job situation, attitudes to safety, perceptions of others' commitment to safety, and perceptions of social support (Mearns et al. 2004). This study, concerned mostly with differences between nationalities, concluded that while country of origin influenced responses to the six scales, installation had a greater influence in explaining differences in accidents.

When taken as a whole, the sum of safety climate research in the offshore has historically favoured accidents as an outcome variable. Recently, there has been a move to examine other health outcomes as there is a relative dearth of research to this effect (Gardner, 2003).

Occupational illness is estimated to have cost a total of $150 billion overall in the US alone, mostly through absenteeism and health care costs (Lazuras et al., 2009). Occupational illness is '*any abnormal condition or disorder caused by exposure to environmental factors associated with employment* (Kelloway & Francis, 2008, p.6).' The study of occupational illness has a long and interesting history. Terms like 'Army Itch,' 'Grinder's Rot,' and 'Railway Brain' have been used in the past to describe illness that are particular to a certain profession (List of Occupational Related Illness, 2010). Today, lists of recognized occupational illness contain over 2000 entries (Voelter-Mahlknecht et al., 2008). Although not as colourfully named as the historical examples given above, a number of occupational illnesses have been identified in the offshore oil industry.

The offshore oil industry is host to a large number of occupational hazards. These include chemical hazards like toxic, corrosive, irritant and sensitizing chemicals and possibly carcinogens. Physical hazards include noise, vibration, various forms of radiation, along with temperature extremes. Biological hazards include legionella and food poisoning. Ergonomic hazards include manual handling and poor workstations.

Psychosocial hazards such as over/under-load of work, work pressure, time away from family or frequent travel are also present and can contribute to psychological stress (Gardner, 2003). There are several features of work on offshore oil platforms that influence the development of these health problems. Physical isolation makes it difficult to plan and monitor employee behavior that may contribute to the development of these illnesses. The exposure to multiple hazards simultaneously may lead to interactions between these hazards that accelerate the development of occupational illness. The focus on major hazards has detracted from a focus on employee health (Gardner, 2003). Although a similar focus in academic research has detracted from the study of employee health, there have been some studies examining certain aspects of the exposure to environmental hazards – occupational illness relationship.

A study conducted in the Norwegian offshore investigated the impact of organizational and environmental factors in the development of occupational illness (Ulleberg & Rundmo, 1997). Environmental factors like noise, draughts, and poor weather in conjunction with perceived satisfaction with safety systems like personal protective equipment, alarm systems, and safety training predicted trouble sleeping and the occurrence of stomach problems. The authors recommended that improvements be made to organizational safety procedures to reduce exposure to hazards. These changes include reducing workload, improving communication, and making safety a higher organizational priority relative to other goals (Ulleberg & Rundmo, 1997).

Musculoskeletal pain can be considered as another type of occupational illness often experienced by offshore workers (Chen et al., 2005). Musculoskeletal pain can be caused by a combination of mechanical and psychosocial factors (Chen et. al, 2005; van de Heuvel, 2005; Warren, 2001). Mechanical factors are heavy physical work like lifting, frequent rotation of the trunk, and whole body vibration, as well as working with the hands at or above shoulder level. Working at a fast pace and working in unsuitable conditions are also associated with neck and shoulder pain (Chen, et. al, 2005; van de Heuvel, 2005; van de Heuvel, 2007). Psychosocial factors associated with musculoskeletal pain appear to include negative work characteristics like ill defined work, decision latitude, social support, and high time pressure/fast work pace (Chen, 2005, 2008; Foppa & Noack, 1996; Lanfranchi, & Duveau, 2008). Skin illness can also be prevalent, as it accounts for 13.6% of all occupational illnesses reported in Europe (European Agency, 2009). White finger illness, caused by high frequency vibration from power tools, is another concern for industrial workers (Voelter-Mahlknecht et al., 2008). These are just some of the types of occupational illness that can affect workers in the offshore oil industry and reflect most of the illnesses measured by the occupational illness section of the TRL.

The same mechanism explaining the relationship between safety climate and acute accidents and injuries described above can be used to describe the relationship between safety climate and the development of occupational illness. Perceptions of safety climate give workers information regarding the relative importance of safety. This information about expected rewards affects motivation, which guides behavior and increases the likelihood of occupational illness.

Providing training and personal protective equipment (PPE) can reduce the occurrence of occupational illnesses like white fingers and skin illnesses (Voelter-Mahlknecht et al., 2008; European Agency, 2009). In this instance, providing this equipment shows a priority on safety, which should translate into the use of PPE by workers as long as use is enforced and encouraged by front line supervisors. A high priority on production implies that workers will be rewarded for working fast or punished for working slowly. Workers then translate this information into behavior like working in awkward positions or without the proper equipment (e.g. lifting aids), causing musculoskeletal pain. Providing access to the proper personal protective equipment (e.g. ear plugs) can reduce the development of hearing loss and in some cases noise-induced stress (Lusk et al., 1997). Communication from management has been linked to reductions in occupational illness related to exposure to chemicals at work by providing employees with information they need to avoid contact with harmful chemicals (Fagotto & Fung, 2002). These examples of safety climate affecting the development of occupational illness all follow the information-reward expectancy-behavior-outcome model that has also been used to describe the mechanism that explains how safety climate leads to acute injuries and accidents (Zohar, 1980).

Safety climate perceptions could also be associated with occupational illness through a stressor - strain relationship as a number of the facets of climate are similar to occupational stressors. The presence of stressors can result in strain which has been associated with occupational illness. For example in the offshore industry strain has been shown to be a predictor of stomach problems (Ulleberg & Rundmo, 1997). A range of occupational illnesses are the result of strain due to factors like increased job demand (Karasek, 1979), lack of social support (Karasek et al., 1982), low control (Karasek, 1990), and production pressure (Chen, 2005, 2008; Foppa & Noack, 1996; Sobeih et al., 2006; Lanfranchi, & Duveau, 2008). It is possible that in contrast to accident involvement, behaviour is not the only mechanism through which safety climate influences the development of occupational illness. Safety climate could be associated with occupational illness as a result of strain and through safety behaviour.

Climate has at least two paths through which it can affect occupational health. It can impact it through behavior, or through stressor strain relationship. Therefore, climate is expected to have a similar, although less robust, relationship to the development of occupational illness as it does with accidents. This will be in addition to the effects of exposure to environmental hazards. Lastly, the offshore oil industry's workforce is aging (Gardner, 2003). Occupational illnesses develop over time, and older offshore workers should be more likely to report instances of occupational illness. As a result, any investigation of occupational illness should qualify for both age and tenure working offshore. Given that the development of occupational illness is a long term process (Gardner, 2003) this relationship is not expected to be as strong as the climate-accident relationship. However, climate should still explain some of the variance in the development of occupational illness.

Hypothesis 1: Self report exposure to hazards will significantly predict the experience of occupational illness after controlling for age and tenure. Perceptions of safety climate will explain additional unique variance beyond what is explained by age, tenure, and exposure to hazards.

Method

Participants

The Petroleum Safety Authority of Norway is a regulatory body that oversees offshore oil drilling on the Norwegian continental shelf. As such, they have access to all employees working in the offshore industry for their bi-annual Trends in Risk Level survey. Participation was voluntary. Surveys were distributed to employees as they began their shifts offshore and were returned as they returned onshore (see Appendix A for survey). Ninety-three percent of the employees surveyed self-identified as being Norwegian, with the other seven percent of workers distributed evenly among 24 other countries. Past versions of the survey attained response rates of 55% for 2001, 50% for 2003, and 50% in 2005 (Tharaldsen, 2008; Hoivik, 2009a). PSA report that the response rate data for the 2007 iteration of the survey was approximately 30%. This is an estimate because it is based on a comparison between the number of person-hours worked during the year and the number of surveys returned. The data set contains responses from 6850 employees from 83 occupations.

Measures

The current study is an archival one that uses an existing data set and survey designed to suit the needs of the PSA and not necessarily academic research. The Trends in Risk Level 2007 questionnaire is a 175 item questionnaire dealing with demographic information, safety climate, risk perception, quality of life, experience of on-the-job stressors, travel and sleep patterns, and the experience of occupational illness. The data set that was available was in Norwegian. This was translated using the website Google Translate, by copying each variable name and label from the SPSS data set, pasting it into the translator, and substituting the translated English back into the data set. Each translation was double checked against an English version of the questionnaire for accuracy. For the purposes of this study, only the revised safety climate, exposure to hazards, and experience of occupational illness scales were used.

Demographics Participants were asked a wide variety of demographic questions on the TRL questionnaire. However, for the purposes of this study the only demographic variables that will be used are length of time working offshore (referred to as tenure for the rest of the document) and age, as occupational illness not acute and develops over time (Voelter-Mahlknecht, 2008). Participants were given the option of responding: 0–1 year, 2-5 years, 6-10 years, 11-19 years, and 20 or more years for length of time working offshore. Participants had the following options when disclosing their age: 20 years or younger, 21-30 years, 31-40 years, 41-50 years, and 61 years or older.

Safety Climate There are 27 items in the revised safety climate scale in the TRL questionnaire (see Study 1). The items are measured on a 5 point Likert-type scale, with 1 being Fully Agree and 5 being Fully Disagree (e.g. At times, I am pressured to work in ways that threaten safety). High scores indicate high levels of agreement, and thus higher perceptions of safety climate.

Exposure to Environmental Hazards In the present version of the survey, 17 items describe exposure to environmental hazards. The items are measured on a 5 point Likert-type scale, with 1 being Very Rarely or Never and 5 being Very Often or Always (e.g. 'Are you exposed to a poor indoor climate?' 'Do you do heavy lifting?' 'Are you exposed to vibrations to your hands or arms from machines or tools?). This scale acts like a checklist of various hazards or strains that workers are exposed to. As such, typical questionnaire statistics like Cronbach's alpha or a factor analysis are not appropriate and won't be reported.

The origin of the items used in this checklist come from research conducted on the Norwegian shelf. Many of the items evolved through a series of studies by Rundmo designed to study risk perception in offshore oil workers. Items were created from examining accident reports published by the Norwegian Petroleum Directorate between 1985 and 1988 (Rundmo, 1992a). Several early versions of the exposure items appear in these preliminary studies (e.g. 'noise/vibrations,' 'cold/hot working climate,' 'perform manual lifting, handling'; Rundmo, 1992a, Rundmo, 1992b). An updated version of these items appears in a 1998 study by Rundmo, again examining safety attitudes of offshore oil workers.

Occupational Illness, Occupational illness is measured by 14 items measured on a 4 point Likert-type scale with 1 being Not Troubled and 4 being Very Troubled (e.g. Reduced hearing, Headache, Stomach/bowel problems). Participants were also asked to check a box if they felt that their illness was caused in part due to their job. I planned to use this information as a multiplier with the ratings of illness to create a more accurate picture of on-the-job related illness, however over 90% of participants did not check this box and as such this information could not be used.

Data Analysis

Factor structures will be explore using exploratory factor analysis and then confirmed using confirmatory factor analysis on a hold out sample. The hypothesis will be tested through a series of hierarchical.

Results

Missing Data

A preliminary review of the data indicated that there were missing data points. A Missing Values Analysis was conducted in SPSS to determine the extent to which data was missing. There were no variables that were missing more than 5% of the data points. When less than 5% of data are missing from a large data set any procedure for handling missing data gives similar results (Tabachnick & Fidell, 2001). As such listwise deletion, the preferred method of dealing with missing values (Roth, 1994), will be used. A total of 1385 cases were removed across the five study variables, leaving a sample size of 5465. Given the large number of excluded participants it was important to ensure that listwise deletion did not incur any unnecessary bias by removing so many cases the means for each item were compared using listwise deletion and mean estimation. The means did not differ by any practical amount between the two methods. As a result listwise deletion remains as the method I chose for dealing with the missing data.

Factor Structure and Reliability

A two part process was undertaken to assess the factor structure of the various scales used in this study. After data cleaning was performed, the data set was split into two subsets based on the assignment of a random number to each case in the data. Then, an exploratory factor analysis (EFA) was performed on the first subset using SPSS 17.0. Once a satisfactory factor structure was obtained it was confirmed using confirmatory factor analysis (CFA) on the second subset using AMOS 17.0. The results of both factor analyses are presented below.

Safety Climate A Principal Components analysis (PCA) was performed on the 27 safety climate items that remained after the sorting task. A Promax rotation was used as previous research on safety climate shows that the factors tend to be correlated (Flin et al., 2000). An initial analysis found a five factor solution. However, eight items were cross-loaded on different factors or had factor loadings less than .30. The items were discarded, leaving 19 items. The factor analysis was re-run with these 19 items. This analysis reported five factors with eigen values greater than 1 and represented 53.89% of the variance. The five factors were labelled as: (1) Accident Prevention (α=.74), (2) Threats to Safety (α=.62), (3) Competence (α=.71), (4) Chemical Knowledge (α=.72) and (5) Training (α=.80). Cronbach's alpha was calculated for factors 4 and 5 using a method for calculating alpha for 2 item measures using covariance matrices (Bohrnstedt, 1969). Communality values for this factor structure ranged from .31 to .85. With the exception of threats to safety the safety climate factors showed acceptable reliability, meeting the standard of α >.70 (Tabachnick & Fidell, 2001).However, safety climate factors with similar alpha's have been used with the TRL questionnaire in the past (Hope et al., 2010). Inter-item correlations ranged from $r = .16$ to $r = .44$. Factor loadings are shown in Table 1. Factor loadings lower than .35 are not included to aid interpretation. See Table 1 for a summary of factor analysis statistics.

The results of the EFA do not match the sorting results from Study 1 or previously reported factor structures (Theraldsen, 2008; Hoivik, 2009). They have a different number of items, with 27 items in the Study 1 factor structure and 19 in the Study 2 factor structure. The item groupings are also not the same.

Table 1

Factor Loadings, Communalities (h^2), and Percent of Variance explained for PCA Promax Rotation for Safety Climate Items

	Accident Prevention	Threats to Safety	Competence	Chemical Knowledge	Training	h^2
Information about undesirable incidents is used efficiently to prevent recurrences	.58					.37
The management takes input from the safety delegates seriously	.59					.53
The safety delegates do a good job	.63					.43
Risk-filled operations are always carefully planned before they are begun	.63					.46
The work permit (WP) system is always adhered to	.63					.40
My supervisor is committed to the HSE work on the facility	.61					.50
Increased cooperation between a facility and land through IT systems has lead to less safe operations		.48				.35
Dangerous situations arise because everyone does not speak the same language		.68				.42
Defficient maintenance has caused poorer safety		.56				.39
At times, I am pressured to work in ways that threaten safety		.51				.41
My lack of knowledge of new technology may sometimes increase accident risk		.66				.51
I doubt that I will be able to perform my emergency preparedness tasks in an emergency		.46				.31
I have the necessary competence to perform my job in a safe manner			.81			.85
I am thoroughly familiar with the HSE procedure			.65			.84
I have easy access to necessary personal protection equipment			.81			.78
I know which chemicals I may be exposed to				.92		.79
I have been informed of the risks associated with the chemicals I work with				.88		.66
I have been given adequate safety training					.84	.61
I have been given adequate working environment training					.83	.64
Percent of Variance	28.7	7.27	6.68	5.81	5.40	

A confirmatory factor analysis (CFA) was conducted on the 19 item safety climate questionnaire to determine the fit of the five factor model found through EFA. The CFA was conducted on the second subset of the data. The five factor model showed generally good fit. Acceptable fit for each measure is as follows: CFI > .90, RMSEA < .05, NFI > .90, RFI > .90, PCLOSE > .05. Fit indices can be found in Table 2.Table 2

Fit indices for a Confirmatory Factor Analysis of the Five Factor Solution of the Safety Climate Scale

Model	χ^2	df	CFI	RMSEA	NFI	RFI	PCLOSE
Five Factor	832	142	.952	.041	.943	.931	1.000

Occupational Illness, A Principal Components Analysis (PCA) was performed on the 14 items from the occupational illness scale contained in the TRL questionnaire using a Varimax rotation. The analysis showed four factors with an eigen value greater than 1. The four factor solution accounted for 49.56% of the variance. The four factors were labelled as: (1) Musculoskeletal Pain (α= .67), (2) Psychosomatic Illness (α= .52), (3) Skin Illness (α= .72) and (4) Auditory Illness (α= .70). Cronbach's alpha was calculated for factors 3 and 4 using a method for calculating alpha for 2 item measures using covariance matrices (Bohrnstedt, 1969). The factor reliabilities were approaching the commonly accepted reliability of α= .70. An alpha of .52 for psychosomatic illness is less than ideal; this may be due to the fact that the illnesses that make up this scale are quite varied, possibly reducing the overall reliability of the scale. Inter-item correlations ranged from .10 to .45. See Table 3 for a summary of factor analysis statistics.

Table 3

Factor Loadings, Communalities (h^2), and Percent of Variance explained for PCA Varimax Rotation on Occupational Illness Items

	Musculoskeletal Pain	Psychosomatic Illness	Skin Illness	Auditory Illness	h^2
Headache	.54				.35
Neck/shoulder/arm pain	.78				.64
Back pain	.74				.56
Knee/hip pain	.66				.46
Eye problems		.41			.27
White fingers		.30			.19
Stomach/bowel problems		.61			.42
Respiratory problems		.56			.41
Cardiovascular problems		.52			.27
Psychological problems (anxiety, depression, sadness, unease)		.64			.45
Skin complaints (eczema, rash)			.30		.71
Allergic reactions/hypersensitivity			.82		.70
Reduced hearing				.85	.75
Ringing in the ears				.85	.76
Percent of Variance	23.6	9.58	8.91	7.52	

A confirmatory factor analysis (CFA) was conducted on the 14 item occupational illness scale using the second half of the data to determine the fit of the four factor model found through EFA. The four factor model showed good fit. Fit indices can be found in Table 4.

Table 4

Fit indices for a Confirmatory Factor Analysis of the Four Factor Solution of the 14 Item Occupational Illness Scale

Model	χ^2	df	CFI	RMSEA	NFI	RFI	PCLOSE
Four Factor	333	71	.954	.036	.942	.926	1.000

Relationship Between Study Variables

See Table 5 for a summary of the correlations between all of the study variables. All correlations were significant, with a general trend of positive relationships between the climate factors and positive relationships between the occupational illness factors. Exposure was positively related to experience of illness and negatively related to perceptions of safety climate. Finally, self-reported experience of illness was negatively related to the safety climate factors.

Table 5

Correlations among the study variables (N=5465)

		Mean	SD	1	2	3	4	5	6	7	8	9	10
1	Exposure to Workplace Hazards	2.44	.61	-									
2	Musculoskeletal Illness	6.42	2.10	.38	(.67)								
3	Psychosomatic Illness	1.21	.28	.27	.43	(.52)							
4	Skin Illness	1.78	.81	.25	.33	.51	(.72)						
5	Auditory Illness	2.81	1.40	.21	.26	.26	.22	(.70)					
6	Accident Prevention	3.65	.49	-.32	-.21	-.20	-.15	-.10	(.74)				
7	Threats to Safety	22.45	4.04	-.41	-.24	-.22	-.16	-.15	.49	(.62)			
8	Competence	13.75	1.68	-.27	-.16	-.17	-.15	-.12	.40	.35	(.71)		
9	Chemical Knowledge	7.90	2.03	-.22	-.15	-.17	-.13	-.09	.50	.37	.36	(.72)	
10	Training	8.42	1.58	-.21	-.14	-.16	-.12	-.07	.50	.32	.34	.44	(.80)

Note: all correlations significant at $p<.001$
Cronbach's alpha on diagonal
Scale responses range from 1-5 for safety climate scales and exposure scale and 1-4 for illness scales

To test hypothesis 1 that safety climate would predict occupational illness above and beyond environmental hazards I conducted a series of hierarchical regressions. Given that both climate and occupational illness are multi-dimensional scales I decided to conduct the analysis using the factors as predictors and outcomes. Four hierarchical regressions were conducted, with one factor of occupational illness as the outcome variable and hazard exposure and the five safety climate factors as predictors. Because occupational illnesses can take as long as 35 years to develop, both age and length of time spent working offshore were used as control variables (Voelter-Mahlknecht, 2008). The control variables were entered together in the first step of the regression. Exposure to environmental hazards was entered in the second step. The five factors of safety climate were entered in the third step.

Musculoskeletal pain was significantly predicted by exposure to environmental hazards ($\Delta R^2 = .15$, $\Delta F = 977.35$, $p < .001$), accident prevention, threats to safety and competence ($\Delta R^2 = .01$, $\Delta F = .02$, $p < .001$). Psychosomatic illness was significantly predicted by exposure to environmental hazards ($\Delta R^2 = .08$, $\Delta F = 447.14$, $p < .001$) and all safety climate factors ($\Delta R^2 = .03$, $\Delta F = 35.02$, $p < .001$). Along with exposure ($\Delta R^2 = .07$, $\Delta F = 363.3$, $p < .001$), only competence and chemical knowledge significantly predicted skin illness ($\Delta R^2 = .01$, $\Delta F = 15.29$, $p < .001$). Exposure to hazards ($\Delta R^2 = .05$, $\Delta F = 363.32$, $p < .001$) along with threats to safety and competence significantly predicted auditory illness ($\Delta R^2 = .01$, $\Delta F = 15.36$, $p < .001$). See Table 6 for a summary of standardized beta weights and Figure 1 for a summary diagram of the relationships.

Table 6

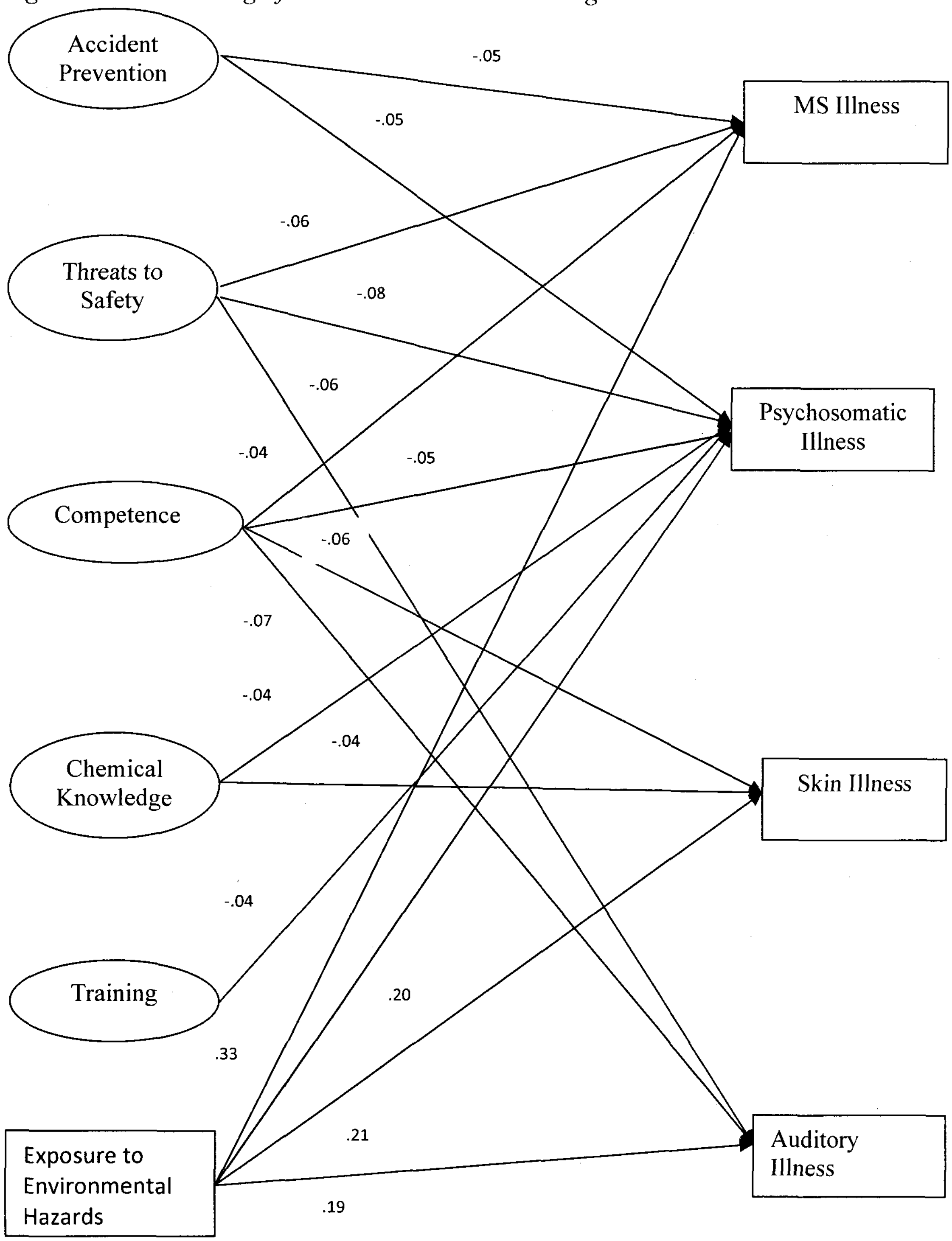
Summary of Hierarchical Regression Analysis for Variables Predicting Occupational Illness

	Illness (N=5465)							
	Musculoskeletal		**Psychosomatic**		**Skin**		**Auditory**	
Step	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
1. *Control Variables*		.03		.02		.01		.06
Age	.08^c		.10^c		.06^b		.19^c	
Tenure	.11^c		.06^c		.05^b		.11^c	
2. *Exposure*		.15		.08		.07		.05
Exposure to Environmental Hazards	.33^c		.20^c		.21^c		.19^c	
3. *Safety Climate Predictors*		.01		.03		.01		.01
Accident Prevention	-.05^a		-.05^b		-.02		.01	
Threats to Safety	-.06^b		-.08^c		-.02		-.06^c	
Competence	-.04^b		-.05^b		-.06^c		-.07^c	
Chemical Knowledge	-.02		-.04^b		-.04^c		-.02	
Training	-.01		-.04^c		-.03		-.01	
Total R^2		**.19**		**.13**		**.09**		**.12**

$^a p < .05$; $^b p < .01$; $^c p < .001$

Figure 1

Diagram to illustrate significant standardized beta weights



Discussion

This study investigated the unique contributions of safety climate above and beyond exposure to environmental hazards in the experience of occupational illness. That exposure to environmental hazards predicted occupational illness consistent with previous research (Gardner, 2003). However, that safety climate added a unique, if small, prediction to this relationship is a novel extension of an existing branch of safety climate theory.

Employee perceptions of safety climate have typically been used to predict acute events like accidents. The proposed mechanism for this relationship is that safety climate offers employees information about the relative importance placed on safety in comparison to other competing goals like production (Zohar, 1980). Employees use this information to infer reward expectancies for either conforming to the behavior or not, which influences the way they interact with to hazards (Bandura, 1986). The current study tested whether or not this relationship held for the climate – occupational illness relationship as well.

The current study used data from the 2007 version of the Trends in Risk Level project undertaken bi-annually by the Petroleum Safety Authority of Norway to examine this relationship. Specifically, a modified safety climate scale, exposure to environmental hazard scale, and the occupational illness scale were used from the TRL questionnaire.

Study 2 had several goals. The first was to analyze the psychometric properties of the modified safety climate scale and the occupational illness scale. I did this using a hold out sample created by splitting the data set in two. Exploratory factor analyses (EFA) were conducted on the first subset of data. Once satisfactory factor structures were decided on, confirmatory factor analyses (CFA) were conducted to determine how well the structures fit in the second subset of data. An EFA conducted on the modified safety climate scale returned five factors labelled as: (1) Accident Prevention, (2) Threats to Safety, (3) Competence, (4) Chemical Knowledge, (5) Training. The five factors showed acceptable reliability, and the factor structure was confirmed on the hold out sample.

This factor structure is quite different from previous findings using the TRL questionnaire. A study using 2003 data reported a five factor structure, while two studies using the 2005 data set reported a six factor structure (Theraldsen, 2008; Hoivik, 2009a; Hope et al., 2010). However, their approach was a purely empirical in that they entered all available items into an EFA. These items included many that did not represent safety climate as it is typically defined (Flin et al., 2000). For example, their 'safety climate' factor structure included items that were more representative of safety behavior (e.g. Neil & Griffin, 2000). The current study addressed these concerns through the sorting method described in Study 1, and the current factor structure appears to be more representative of the definition of safety climate used in this study (Flin et al., 2000). I will note that the factor structure proposed in Study 2 was quite different from the structure of the sorted items in Study 1. This illustrates the difficulties present in trying to theoretically derive factor structures

An EFA was performed on the occupational illness scale. A four factor solution emerged, was labelled as: (1) Musculoskeletal Pain, (2) Psychosomatic Illnesses, (3) Skin Illnesses, (4), Auditory Illnesses.

Once the psychometric properties of the TRL questionnaire were analyzed, four hierarchical regression analyses were carried out to determine the contributions of safety climate and exposure to hazards on occupational illness. Two demographic variables, age and tenure, were used as controls as occupational illnesses are not acute and develop over time and exposure (Voelter-Mahlknecht, 2008). Correlational evidence supported this finding in the current study, with both age and tenure showing significant positive correlations with occupational illness. Age and tenure were also significant predictors for each of the four factors of occupational illness. This suggests that the development of occupational illness is at least in part a by-product of aging. Older workers, particularly in the manual labour sector, are more prone to injury, in poorer shape, and slower to recover than their younger peers. They are also simply exposed to hazards longer, creating a cumulative effect (Mackey et al., 2007). As workforces in many industries experience the effects of an aging workforce, employers should be prepared for the increased costs associated with this.

Hypothesis 1 was supported, with a) exposure to hazards predicting occupational illness above and beyond age and tenure, and b) perceptions of safety climate predicting occupational illness above and beyond exposure to hazards. An interesting finding was that exposure to hazards explained more variance in occupational illness than did climate, explaining approximately five times as much variance as did safety climate, suggesting that safety climate is not as important as exposure to hazards in predicting occupational illness. This is consistent with previous research stating that safety climate does not explain much, if any variance when environmental hazards are used as a predictor (Smith et al., 2006).

The individual factors of safety predicted different occupational illness outcomes. Competence predicted all four occupational illness outcomes Accident prevention predicted musculoskeletal and psychosomatic illness, but not skin or auditory illness. Threats to safety predicted all factors of occupational illness except for skin illness. Chemical knowledge was a significant predictor of skin illness only. Training was a predictor of all outcomes except for auditory illnesses.

Showing that safety climate predicts occupational illness is an important consideration for employers not only in industrial industries like the offshore oil industry, but any industry where occupational illnesses develop. For example, occupations as varied as meat cutting, farming, dentistry, keyboarding and mining all experience neck and shoulder pain (Hagberg & Wegman, 1987). Organizations in these industries can learn from the findings of this study and lessen the development of this type of occupational illness by elevating the importance of work safety along with putting control measures in place to lessen exposure to environmental hazards and stress. In addition, as safety climate is a specific form of an overall organizational culture (Guldenmund, 2000), the perception of importance – behavior – outcome relationship may be able to be applied to other specific forms of workplace climate. For example, placing importance on civility at work may lead employees to alter their behavior to conform to this organizational value and act with less incivility towards their co-workers.

Behavior is an important mechanism in the safety-health outcome relationship. Unfortunately, safety behaviour's role in this mechanism is not often tested and is merely inferred (Griffin & Neal, 2000). I initially proposed to test this relationship using several items contained within the original TRL 'safety climate' scale. Study 1 made provisions for this by sorting relevant safety behavior items together based on Griffin and Neal's (2000, 2006) safety behavior framework. Unfortunately these items showed extremely poor internal reliability with a Cronbach's α of less than .30 when grouped together as a scale. The plan to test safety behavior as a mediator was abandoned as a result. However, I am disappointed that I was unable to test this important piece of the safety climate – health outcome relationship. Future research, using the TRL questionnaire or otherwise, should continue to attempt to test this relationship to provide more detail on the full spectrum of the safety climate – health outcome relationship.

Implications for Practice

Occupational illnesses are costly to employers and employees (Lazarus, 2009). As such employers may want to investigate ways to reduce the occurrence of these illnesses. The results of the current study indicate that if an employer wishes to have the greatest impact on the development of occupational illness they should improve their method for controlling hazards. Exposure to environmental hazards is the strongest predictor of occupational illness outcomes so this should be the main area given attention by organizations. Safety climate, while only accounting for a small amount of variance in occupational illness, can be another avenue through which organizations reduce instances of occupational illness.

The accident prevention factor represents management commitment to safety, communication and planning. This factor was shown to be a predictor of musculoskeletal and psychosomatic illnesses. To address these forms of illness from the perspective of commitment to safety, communication and planning management may want to consider implementing practices to increase communication. Operating companies should ensure that input from employee consultation is highlighted in the decision making process. Actions taken to prevent the reoccurrence of incidents should be clearly communicated to employees through toolbox talks, safety meetings, and safety alerts. Lastly, supervisors should be trained in safety leadership and have the skills to demonstrate commitment.

The safety climate factor Threats to Safety predicts all occupational illness factors except for skin illness. As such this may be a good area for employers to address. This factor touches on the lack of pre-emptive safety for example, deficient maintenance. The best way for management to address these short comings is involve frontline staff in the setting of maintenance priorities and to provide a confidential reporting system to enable to frontline staff to raise maintenance concerns. Regular maintenance is important for the smooth operation of any industry.

Competence predicts all four occupational illness factors and contains items that assess feelings of competence and knowledge of procedures. Making sure that employees are properly trained is a good idea not only for safety but for the organization in general.

It is important that organisations go beyond merely providing training and develop quality assurance process that measure employee competence on the job. At a minimum, companies should survey workers about their perceived competence to perform the tasks in a safe manner.

Training reflects employee's satisfaction with the amount of safety training they have received. To address this, employers should involve employees in developing their own personalised training matrix and provide adequate resources for training. In addition, employees, especially new ones, should be given job-specific training to address specific safety concerns of individual jobs or work areas.

These are just some areas that employers can address the development of occupational illness at work. At a general level, showing commitment to safety and the health of worker's is the best way to address occupational illness.

General Discussion

This study combined a qualitative examination of an existing safety climate scale with a data driven analysis of a novel extension of a pre-existing model of the relationship between safety climate and health. Using data obtained from the 2007 version of the Petroleum Safety Authority's Trends in Risk Level questionnaire I was able to show that safety climate explained variance in occupational illness above and beyond exposure to environmental hazards. This was tested in the context of the offshore oil industry, but may be applicable across industries and other specific workplace cultures.

Working with an existing, organizationally collected database was both interesting and challenging. It presented several limitations, many of which resulted in recommendations for the future of the TRL research project.

Limitations and Future Research

There are several limitations to the current study. The first was that this study was designed from an existing data set and questionnaire. In one sense data collection is already performed, which saves time. In another, forcing theoretical relationships on scales that were not designed to measure them can be a difficult and frustrating process. This made for an interesting experience overall and presented some specific difficulties.

The first limitation is that the Trends in Risk Level study is designed to suit the needs of the Petroleum Safety Authority of Norway is and not tailored to investigating specific research questions. This applies most directly to the safety climate scale, necessitating the development of the sorting task described in Study 1.

Another limitation was that the data were nested by both installation and supervisor. However, this information was not included with the data provided by the PSA. This is unfortunate as using the nested structure of offshore oil work would have added more depth to the analysis, as previous research has found that differences in safety climate can be attributed to installation more so than other factors (e.g. Hoivik, 2009a). Also, individual supervisors may have an impact on employee perceptions of safety climate (Zohar, 2005). Analyzing nested data without taking this information into account can lead to incorrect results, as this often inflates relationships (Degenholtz & Bhatnagar, 2009). Therefore the results need to be treated with caution.

Finally, mono-method bias may have been an issue as both the endogenous and exogenous were taken from the same survey. Mono-method bias can inflate effects. This, coupled with the large sample size (N=5465), may have made it more likely that smaller effect sizes achieved significance.

Recommendations for the TRL questionnaire

There are several areas where the TRL instrument could be improved. Many of the items are double, or even triple barrelled. For instance, the item '*Do you experience difficulties seeing what you are doing due to insufficient, weak, or blinding light*' is really referring to three different types of lighting conditions. Another problem with the TRL safety climate scale is that the items differ in terms of specificity. For example, the items '*Risk filled operations are always carefully planned before they are begun,*' and '*I know which chemicals I am exposed to,*' refer to two very different processes, one being high level organizational policy and planning, and the other a very specific individual perception of the worker's awareness. Grouping these types of items together makes analysis much more difficult and the PSA may want to address this by either redesigning the survey to match one level of specificity or by splitting the overall safety climate scale into smaller sub-scales. I recommend that the items be revised to be less ambiguous and to remove double barrelled items. However, I do not know to what extent these problems are present in the Norwegian language version of the questionnaire. Ninety-three percent of the respondents in the current survey self-identified as being Norwegian. If the wording issues of the questionnaire are not present in Norwegian then this recommendation is not appropriate. The PSA may also want to investigate the possibility of obtaining ratio data instead of categorical for many of the demographic variables. For example, both the age and tenure variables used in this study were categorical. Ratio data (e.g. specific age instead of a range) would be much more useful from an analysis standpoint.

Construct driven scale development is preferable to a more empirical process of item development followed by factor analysis to arrive at a scale. Developing construct driven scales involves starting with theoretically founded constructs (e.g. management commitment). The next step is to develop items to measure these constructs. Finally, factor analytic techniques are used to confirm that the items actually measure the proposed constructs. Construct based scales and the results derived from their use are more generalizable and facilitate the development of more effective interventions. It also gives focus to recommendations stemming from research using the scale, as typically theoretically derived scales are based on one or more theories of behavior. One example of a theoretically concept that is used to construct questionnaires is management commitment. Management commitment to safety is both theoretically based and is accepted almost universally as an important factor of safety climate (e.g. Zohar, 1980, 2000, 2005). This is an excellent example of a construct that is theoretically derived and useful for specific industries while at the same time being generalizable across them.

Finally, the TRL is a rich source of data and covers many facets of offshore life not touched on in this study, like sleep patterns, quality of life, and risk perception.

Future research using this instrument should continue probing the data contained within it. For example, a recent study by Hope et al., (2010) investigated the effects of risk perception on sleep. This is a novel area in offshore research, but an important one given the nature of working on an offshore oil installation.

Conclusion

Research on working in the offshore oil industry on the Norwegian continental shelf is now entering its fourth decade. With beginnings in risk perception and safety climate research by a host of researchers, safety research on the NCS has culminated in the bi-annual Trends in Risk Level project undertaken by the Petroleum Authority of Norway.

Using data from the 2007 version of the TRL questionnaire, the current study was able to show for the first time that safety climate and exposure to environmental hazards both impact the development of occupational illness in offshore workers. Differential prediction of the four factors of occupational illness by the five factors of safety climate was shown through a combination of hierarchical regression and structural equation modelling. The current study was also able to highlight several areas of the questionnaire that can be improved psychometrically to make future versions of the TRL questionnaire more amenable to academic research and analysis. Future research should also investigate other novel relationships that may be found in the TRL data.

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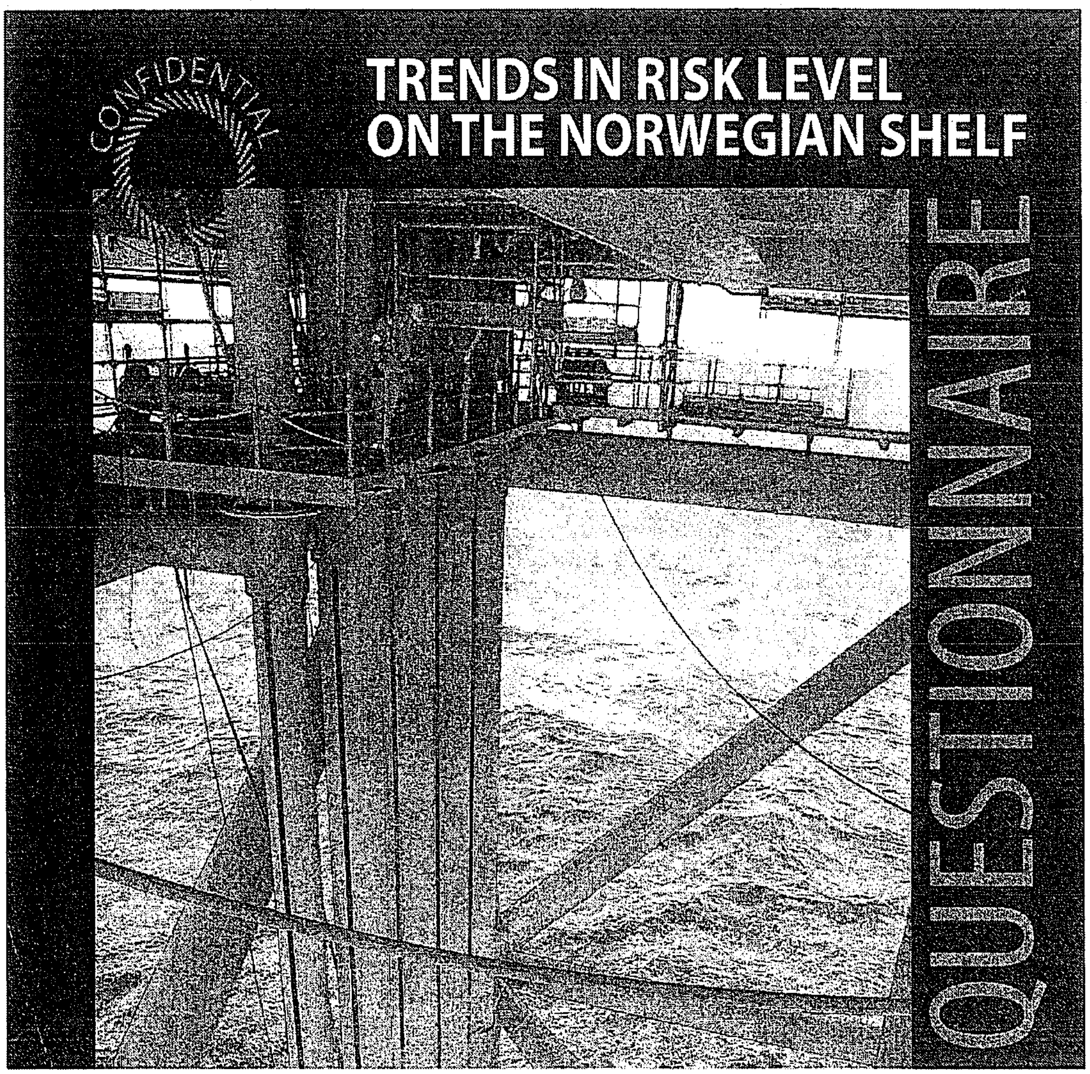
Appendix A

PETROLEUM SAFETY AUTHORITY NORWAY

IRIS
International Research Institute of Stavanger



Fellesforbundet SAFE DSO

Norsk Industri Lederne OLJEINDUSTRIENS LANDSFORENING NORGES REDERIFORBUND

Dear offshore employee

Since 2000, the Petroleum Safety Authority Norway has been conducting a project – Trends in Risk Level - to map the HSE situation on the Norwegian shelf. The project is conducted in close cooperation with the Safety Forum, which is made up of representatives from relevant authorities, employers and employee organizations. The following organizations are members of the Safety Forum: DSO, Fellesforbundet, IE, Lederne, LO, Norwegian Shipowners' Association, Norsk Industry, OLF and SAFE.

The purpose of the project is to monitor trends in the HSE situation over time, so that measures can be taken to correct any unfortunate trends and contribute to general HSE improvements in the industry.

As part of this project, a questionnaire is distributed to all offshore employees every two years.
The questionnaire applies to HSE work offshore, and includes the following issues:

- Safety
- Working environment
- Assessment of own health

Please answer the questions on the following pages during your stay offshore.

Please put the completed form in the attached envelope and then in the return boxes set up on the facility. When the return boxes are full, they will be sealed and forwarded to the International Research Institute of Stavanger (IRIS), which is responsible for the practical organisation of the questionnaire survey.
The forms are confidential and results will be made anonymous so that no individuals can be identified. Everyone at IRIS working on the survey is subject to a confidentiality clause.

The questionnaire can also be filled in electronically. We call on everyone who can to avail themselves of this opportunity. To take the survey, enter the following address in the browser:

www.iris.no/websurveys

You will then be asked to enter a number. This number is printed in red at the top of the page. The number is for administrative use, and also makes it safer to complete the form in this manner. It is not linked to a name or anything else which can identify you. If the whole form is not completed at once, you must use the number again to reenter the form. If you complete the form online, the paper form should not be submitted by you or anyone else. Keep the form if you like, or discard it.

Any questions can be directed at

Brita Gjerstad, IRIS (tel.: +47 51 87 50 84, e-mail bg@iris.no)
Thomas Lorentzen, IRIS (tel.: +47 55 54 38 65, e-mail thl@iris.no)
Øyvind Lauridsen, the Petroleum Safety Authority Norway (tel.: +47 51 87 60 21, e-mail oyvind.lauridsen@ptil.no)

Thank you for participating!

Important! This form will be read electronically. Therefore, it is important that it is filled in carefully. Please use a blue or black pen.

Mark the box like this: [X] If you marked the wrong box, delete the incorrect answer as indicated: ■

Please use capital letters when filling in text fields as indicated:

M	E	C	H	A	N	I	C

Numbers should be written like this:

0	1	2	3	4	5	6	7	8	9

When answering, please mark the boxes like this: "X"

1. **Sex**

☐ Male ☐ Female

2. **Age**

☐ 20 years or younger ☐ 21-30 years ☐ 31-40 years
☐ 41-50 years ☐ 51-60 years ☐ 61 years or older

3. **Nationality. Please use block letters.**

4. **Which sort of education do you have?**

☐ Apprentice ☐ Unskilled ☐ University ☐ Upper secondary school (no trade certificate)
☐ Skilled with one trade certificate ☐ Skilled with more than one trade certificate ☐ Trade-specific certificate(s)

5. **If you replied "trade-specific certificates(s)": which ones? Please use capital letters.**

6. **Approx. how much of your working hours during the last year have been spent...**

	None at all	1 - 24 per cent	25 - 49 per cent	50- 74 per cent	75 - 100 per cent
offshore	☐	☐	☐	☐	☐
in oil/gas-related activities on land	☐	☐	☐	☐	☐
in other work/education	☐	☐	☐	☐	☐

7. **How long have you worked offshore?**

☐ 0 - 3 mo. ☐ 4 mo. - 1 year ☐ 2 - 5 years
☐ 6 - 10 years ☐ 11 - 19 years ☐ 20 years or more

8. **Which company are you employed in? Please use capital letters.**

9. **Do you have permanent or temporary employment?**

☐ Permanent ☐ Temporary

10. **What is your position title? Please use capital letters.**

11. **How long have you been employed in your present position?**

☐ 0 - 3 mo. ☐ 4 mo. - 1 year ☐ 2 - 5 years
☐ 6 - 10 years ☐ 11 - 19 years ☐ 20 years or more

12. **In what area do you work? If you work within several areas, select the one most appropriate for your position.**

☐ Process ☐ Drilling ☐ Well service ☐ Catering ☐ Construction/ modification

☐ Maintenance ☐ Crane/deck ☐ Administration ☐ Other

13. If you replied "other", please specify. Use capital letters.

14. Do you have management responsibilities?

☐ No ☐ Yes, with personnel responsibility ☐ Yes, without personnel responsibility

15. Do you work in permanent offshore rotation?

☐ Yes ☐ No

16. What is your current shift arrangement?

☐ Permanent day shift ☐ Permanent night shift ☐ Fixed shift (14 nights/14 days every second tour)

☐ Swing shift with 7 nights first, then 7 days ☐ Swing shift with 7 days first, then 7 nights ☐ Shift arrangements vary

17. What is the name of the installation where you are currently working?

18. Do you work permanently on this installation?

☐ Yes, every tour ☐ Yes, mostly ☐ No, it varies

19. During a typical work period, how often do you travel by helicopter between your place of work and your accommodation ("shuttling" to other accommodation offshore or commuting onshore for hotel accommodation)?

☐ Always/nearly always ☐ A few times during the period ☐ Never/almost never ☐ Varies much from period to period

20. Have you been assigned any emergency preparedness functions?

☐ Yes ☐ No

21. If yes, tick the boxes for your assigned emergency preparedness function(s).

☐ Lifeboat coxswain ☐ Fire team ☐ Man-over-board boat (MOB boat) ☐ First aid

☐ Helicopter landing officer (HLO) ☐ Rescue leader ☐ Emergency team leader ☐ Other

22. If you replied "other", please specify. Use capital letters.

23. Do you currently hold the office of...

	Yes	No
Employee representative?	☐	☐
Safety delegate?	☐	☐
Member of working environment committee?	☐	☐

24. Have you done the mandatory 40-hour basic course for safety delegates and members of working environment committees?

- ❑ Yes
- ❑ No

25. During last year, have you experienced reorganisations that affect the way you plan and/or carry out your work on the facility?

- ❑ I have experienced reorganisations with significant consequences
- ❑ I have experienced reorganisations with moderate consequences
- ❑ I have experienced reorganisations without significant consequences for my work
- ❑ I have not experienced reorganisation

26. During the last year, has your workplace been subjected to workforce reductions or redundancies?

- ❑ Yes
- ❑ No

27. During the last year, have you experienced changes in your work situation as a result of land and offshore being more closely connected through modern information technology?
(for instance integrated operations, moving work tasks to land, remote control, remote support, remote monitoring or similar)

- ❑ Yes
- ❑ No

28. Below are some statements of importance to health, working environment and safety (HSE). Some statements only apply to working environment or safety. Based on your experiences from your workplace, indicate to what degree you agree with the various statements by marking one box for each statement with an "x"..

	Fully agree	*Partially* agree	Neither agree nor disagree	*Partially* disagree	*Fully* disagree
Risk-filled operations are always carefully planned before they are begun	❑	❑	❑	❑	❑
At times, I am pressured to work in ways that threaten safety	❑	❑	❑	❑	❑
My lack of knowledge of new technology may sometimes increase accident risk	❑	❑	❑	❑	❑
There is enough manning to properly safeguard HSE	❑	❑	❑	❑	❑
I have the necessary competence to perform my job in a safe manner	❑	❑	❑	❑	❑
I have easy access to necessary personal protection equipment	❑	❑	❑	❑	❑
I am thoroughly familiar with the HSE procedures	❑	❑	❑	❑	❑
The management takes input from the safety delegates seriously	❑	❑	❑	❑	❑
My workplace is often messy	❑	❑	❑	❑	❑
I feel uncomfortable pointing out breaches of safety rules and procedures	❑	❑	❑	❑	❑

	Fully agree	Partially agree	Neither agree nor disagree	Partially disagree	Fully disagree
The work permit (WP) system is always adhered to					
I can influence HSE matters at my workplace					
I sometimes breach safety rules in order to get a job done quickly					
It is easy to be seen as a quarrelsome person if you point out hazardous conditions					
In practice, production takes priority over HSE					
Information about undesirable incidents is used efficiently to prevent recurrences					
I use mandatory personal protection equipment					
I do not participate actively in HSE meetings					
Being too preoccupied with HSE can be a disadvantage to your career					
Communication between me and my colleagues often fail in a way that may lead to dangerous situations					
The HSE laws and regulations are not good enough					
I would rather not discuss HSE with my immediate supervisor					
Deficient maintenance has caused poorer safety					
I stop work if I believe that it may dangerous for me or others to continue					
My manager appreciates my pointing out matters of importance to HSE					
I have been given adequate safety training					
I have been given adequate working environment training					
My colleagues will stop me if I work unsafely					
I doubt that I will be able to perform my emergency preparedness tasks in an emergency					
There are often concurrent work operations which lead to dangerous situations					
The accident preparedness is good					
Reports about accidents or dangerous situations are often "embellished"					

	Fully agree	Partially agree	Neither agree nor disagree	Partially disagree	Fully disagree
I ask my colleagues to stop work which I believe is performed in an unsafe manner	❑	❑	❑	❑	❑
The company I work for takes HSE seriously	❑	❑	❑	❑	❑
Lack of cooperation between operators and contractors often lead to dangerous situations	❑	❑	❑	❑	❑
I report any dangerous situations I see	❑	❑	❑	❑	❑
Safety is my number one priority when I work	❑	❑	❑	❑	❑
My supervisor is committed to the HSE work on the facility	❑	❑	❑	❑	❑
It is easy to tell the nurse/company health service about complaints and illnesses that might be work-related	❑	❑	❑	❑	❑
My colleagues are very committed to HSE	❑	❑	❑	❑	❑
I am unsure about my role in the emergency preparedness organisation	❑	❑	❑	❑	❑
The safety delegates do a good job	❑	❑	❑	❑	❑
I think it is easy to find what I need in the governing documents (requirements and procedures)	❑	❑	❑	❑	❑
I always know who to report to in the organisation	❑	❑	❑	❑	❑
The HSE procedures cover my work tasks	❑	❑	❑	❑	❑
Different procedures and routines at different facilities may pose a threat to safety	❑	❑	❑	❑	❑
I feel sufficiently rested when I am at work	❑	❑	❑	❑	❑
The equipment I need to carry out my work safely is easily available	❑	❑	❑	❑	❑
I have easy access to procedures and instructions concerning my work	❑	❑	❑	❑	❑
Increased cooperation between a facility and land through IT systems has lead to less safe operations	❑	❑	❑	❑	❑
I feel a group pressure which affects HSE assessments	❑	❑	❑	❑	❑
I have access to the information necessary to make decisions which ensure the HSE aspect	❑	❑	❑	❑	❑
Dangerous situations arise because everyone does not speak the same language	❑	❑	❑	❑	❑
I know which chemicals I may be exposed to	❑	❑	❑	❑	❑
I have been informed of the risk of the chemicals I work with	❑	❑	❑	❑	❑
There have been dangerous situations because people have been under the influence of alcohol or drugs at work	❑	❑	❑	❑	❑

29. Below is a list of some hazard and accident situations which may occur on the facilities. Please state how much of a hazard you feel the different situations constitute to you. Mark with an "X".

	Very slight hazard (1)	(2)	(3)	(4)	(5)	Very great hazard (6)
Helicopter accident	☐	☐	☐	☐	☐	☐
Gas leak	☐	☐	☐	☐	☐	☐
Fire	☐	☐	☐	☐	☐	☐
Explosion	☐	☐	☐	☐	☐	☐
Blowout	☐	☐	☐	☐	☐	☐
Emissions/discharge of toxic gases/substances/chemicals	☐	☐	☐	☐	☐	☐
Radioactive sources	☐	☐	☐	☐	☐	☐
Collisions with ships/vessels/floating objects	☐	☐	☐	☐	☐	☐
Sabotage/acts of terror	☐	☐	☐	☐	☐	☐
Collapse of the installation's load-bearing structures or loss of buoyancy	☐	☐	☐	☐	☐	☐
Serious work accidents	☐	☐	☐	☐	☐	☐
Falling objects	☐	☐	☐	☐	☐	☐
IT systems failure	☐	☐	☐	☐	☐	☐

30. Below is a list of some matters concerning <u>free periods</u> offshore. Indicate how often you are inconvenienced by these issues by marking one box for each question with an "X".

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Is there disturbing noise in the public rooms in the accommodation quarters?	☐	☐	☐	☐	☐
Is there disturbing noise in your cabin?	☐	☐	☐	☐	☐
Do you find the indoor climate poor in the public areas of the accommodation quarters?	☐	☐	☐	☐	☐
Do find the indoor climate poor in your cabin?	☐	☐	☐	☐	☐
Are the accommodation quarters clean and tidy?	☐	☐	☐	☐	☐

31. Indicate how satisfied or dissatisfied you are with the different matters. Mark with an "X"

	Very satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Very dissatisfied
Quality of food and drink	☐	☐	☐	☐	☐
Cabin conditions	☐	☐	☐	☐	☐
Exercise opportunities	☐	☐	☐	☐	☐
Other recreational opportunities	☐	☐	☐	☐	☐
Comfort during helicopter transport	☐	☐	☐	☐	☐

32. Below is a list of some questions concerning your work situation offshore. Indicate your experience of the various issues by marking one box for each question with an "X".

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Are you exposed to noise levels that are so high that you have to stand close to people and shout to be heard, or have to use headsets?	☐	☐	☐	☐	☐
Are you exposed to vibrations to your hands or arms from machines or tools?	☐	☐	☐	☐	☐
Do you work in cold areas exposed to the weather?	☐	☐	☐	☐	☐
Are you exposed to a poor indoor climate?	☐	☐	☐	☐	☐
Do you experience difficulties seeing what you are doing due to insufficient, weak or blinding lighting?	☐	☐	☐	☐	☐
Is your skin exposed to contact with e.g. oil, drilling mud, detergents or other chemicals?	☐	☐	☐	☐	☐
Can you smell chemicals or clearly see smoke or dust in the air?	☐	☐	☐	☐	☐
Do you do heavy lifting?	☐	☐	☐	☐	☐
Do you do repetitive and monotonous movements?	☐	☐	☐	☐	☐
Do you work in difficult work positions (e.g. arms above shoulders, bent/twisted back/neck)?	☐	☐	☐	☐	☐
Is it necessary to work very fast?	☐	☐	☐	☐	☐
Do you find the shift arrangement a strain?	☐	☐	☐	☐	☐
Do you work so much overtime that it is a strain?	☐	☐	☐	☐	☐
Do you get sufficient rest/recreation between workdays?	☐	☐	☐	☐	☐
Do you get sufficient rest/recreation between work periods?	☐	☐	☐	☐	☐
Is your workplace well adapted to the work tasks you perform?	☐	☐	☐	☐	☐
Does your new work require so much attention that you find it a strain?	☐	☐	☐	☐	☐
Is your work challenging in a positive way?	☐	☐	☐	☐	☐
Do you have to acquire new knowledge and skills because of your job?	☐	☐	☐	☐	☐

	Very rarely or never	Quite rarely	Sometimes	Quite often	Very often or always
Does your immediate supervisor value your work results?	☐	☐	☐	☐	☐
Can you set your own work speed?	☐	☐	☐	☐	☐
Can you influence decisions which are important to your work?	☐	☐	☐	☐	☐
Can you influence the way you perform your work?	☐	☐	☐	☐	☐
Do your colleagues help and support you in your work, if you need it?	☐	☐	☐	☐	☐
Does your immediate supervisor help and support you in your work, if you need it?	☐	☐	☐	☐	☐
Do you feel that the cooperation climate in your work unit is encouraging and supportive?	☐	☐	☐	☐	☐
Do you have so many tasks that it becomes hard to concentrate on each one?	☐	☐	☐	☐	☐
Does your immediate supervisor give you feedback on your work performance?	☐	☐	☐	☐	☐
Do you get necessary training in the use of new IT systems?	☐	☐	☐	☐	☐
Do the IT systems you use provide the necessary support in the performance of your work tasks?	☐	☐	☐	☐	☐

33. Do you feel sure that you will have a job as good as the one you have now in two years' time?

☐ Very sure ☐ Fairly sure ☐ Somewhat sure ☐ Fairly unsure ☐ Very unsure

34. Over the last six months, have you been subjected to repeated bullying and harassment at your workplace?

☐ Yes ☐ No

35. If yes, by whom? Feel free to mark more than one box with an "X".

☐ Colleagues ☐ Supervisor(s) ☐ Subordinates ☐ Others at the facility

36. Indicate how often you feel the various statements apply to you by marking one box per statement with an "X".

	Very often or always	Quite often	Sometimes	Quite rarely	Very rarely or never
I sleep well when offshore	☐	☐	☐	☐	☐
I sleep well the last few nights before going offshore	☐	☐	☐	☐	☐
I sleep well the first few nights after an offshore tour	☐	☐	☐	☐	☐
I have a problem with noise when sleeping offshore	☐	☐	☐	☐	☐
I must share cabins with others when I sleep	☐	☐	☐	☐	☐

37. **How many hours**

	Hours
... were you awake before going on your first shift?	☐☐
...overtime did you work on your last tour?	☐☐

38. **How many days did you spend offshore on your last tour?**

☐☐

39. **Have you worked more than 16 hours during the course of a 24-hour period one or more times during the last year?**

☐ Yes ☐ No

41. **During your last offshore tour, were you woken up in your free time to do a work task?**

☐ Yes ☐ No

42. **Do you normally have one or more additional jobs when you are on land between offshore tours?**

☐ Yes ☐ No

HEALTH

43. **Have you been absent from work because you have been ill during the last year?**

☐ Yes ☐ No

The next two questions should only be answered if you said yes to the last question.

44. **How many days have you been absent from work due to illness during the last year?**

☐ 1-14 days ☐ More than 14 days

45. **Do you believe that your last sick leave period was fully or partly caused by your work situation?**

☐ Yes ☐ No

46. **Have you been injured in a work accident while at the facility during the last year?**

☐ Yes ☐ No

47. **If yes, was the injury reported to your supervisor?**

☐ Yes ☐ No

48. **If so: How was the injury classified?**

☐ First aid ☐ Medical treatment ☐ Alternative work

☐ Lost time injury ☐ Serious lost time injury

49. **Working capacity**

	Very good	Quite good	Moderate	Quite poor	Very poor
How do you evaluate your own work capacity with respect to the physical demands at work?	☐	☐	☐	☐	☐
How do you evaluate your own work capacity with respect to the psychological demands at work?	☐	☐	☐	☐	☐

50. Over the last three months, have you been troubled by any of the following:

	Not troubled	A little troubled	Quite troubled	Very troubled	Mark ("X") here if you feel that your symptoms are fully or partially caused by your work situation
Reduced hearing	☐	☐	☐	☐	☐
Ringing in the ears	☐	☐	☐	☐	☐
Headache	☐	☐	☐	☐	☐
Neck/shoulder/arm pain	☐	☐	☐	☐	☐
Back pain	☐	☐	☐	☐	☐
Knee/hip pain	☐	☐	☐	☐	☐
Eye problems	☐	☐	☐	☐	☐
Skin complaints (eczema, rash)	☐	☐	☐	☐	☐
White fingers	☐	☐	☐	☐	☐
Allergic reactions/hypersensitivity	☐	☐	☐	☐	☐
Stomach/bowel problems	☐	☐	☐	☐	☐
Respiratory problems	☐	☐	☐	☐	☐
Cardiovascular problems	☐	☐	☐	☐	☐
Psychological problems (anxiety, depression, sadness, unease)	☐	☐	☐	☐	☐

51. How would you generally describe your health?

☐ Very good ☐ Good ☐ Neither good nor poor ☐ Poor ☐ Very poor

52. We have now asked all our questions. If you have opinions or comments to the topics raised in this form or in your answers, you can write them here. Please use capital letters.

Appendix B

Sorting Results

Item	Category Sorted In: SME 1	SME 2	Agreement
Risk-filled operations are always carefully planned before they are begun	Safety systems	Safety systems	Yes
At times, I am pressured to work in ways that threaten safety	Management	Management	Yes
My lack of knowledge of new technology may sometimes increase accident risk	Competence	Competence	Yes
There is enough manning to properly safeguard HSE	Other	Other	Yes
I have the necessary competence to perform my job in a safe manner	Competence	Competence	Yes
I have easy access to necessary personal protection equipment	Safety systems	Safety systems	Yes
I am thoroughly familiar with the HSE procedures	Competence	Competence	Yes
The management takes input from the safety delegates seriously	Management	Management	Yes
My workplace is often messy	Other	Other	Yes
I feel uncomfortable pointing out breaches of safety rules and procedures	Other	Rules and procedures	No
The work permit system(WP) system is always adhered to	Safety systems	Safety systems	Yes
I can influence HSE matters at my workplace	Other	Other	Yes
I sometimes breach safety rules in order to get a job done quickly	Safety performance	Safety performance	Yes
It is easy to be seen as a quarrelsome person if you point out hazardous conditions	Other	Other	Yes
In practice, production takes priority over HSE	Management	Management	Yes
Information about undesirable incidents is used efficiently to prevent recurrences	Info	Info	Yes
I use the mandatory personal protective equipment	Safety systems	Safety performance	No

I do not participate actively in HSE meetings	Safety performance	Safety performance	Yes
Being too preoccupied with HSE can be a disadvantage to your career	Other	Other	Yes
Communication between me and my colleagues often fail in a way that may lead to dangerous situation	Other	Info	No
The HSE laws and regulations are not good enough	Rules and procedures	Rules and procedures	Yes
I would rather not discuss HSE with my immediate supervisor	Management	Info	No
Deficient maintenance has caused poorer safety	Safety systems	Safety systems	Yes
I stop work if I believe that it my be dangerous for me or others to continue	Safety performance	Safety performance	Yes
My manager appreciates my pointing out matters of importance to HSE	Management	Management	Yes
I have been given adequate safety training	Competence	Competence	Yes
I have been given adequate working environment training	Competence	Competence	Yes
My colleagues will stop me if I work unsafely	Other	Safety performance	No
I doubt that I will be able to perform my emergency preparedness tasks in an emergency	Competence	Competence	Yes
There are often concurrent work operations which lead to dangerous situations	Other	Safety systems	No
The accident preparedness is good	Rules and Procedures	Other	No
Reports about accidents or dangerous situations are often 'embellished'	Info	Info	No
I ask my colleagues to stop work that I believe will be conducted in a risky manner	Safety performance	Safety performance	Yes
The company I work for takes the HSE takes seriously	Other	Other	Yes
Lack of cooperation between operators and contractors often leads to a dangerous situation	Other	Info	No
I report any dangerous situations I see	Safety performance	Safety performance	Yes
Safety is my number one priority when I work	Other	Other	Yes
My supervisor is committed to the HSE work on the facility	Management	Management	yes

It is easy to tell the nurse/company health service about complaints and illnesses that might be work-related	Other	Info	No
My colleagues are very committed to HSE	Other	Other	Yes
I am unsure about my role in the emergency preparedness organisation	Other	Other	Yes
The safety delegates to a good job	Safety systems	Safety systems	Yes
I think it is easy to find what I ned in the governing documents (requirements and procedures)	Info	Rules and procedures	No
I always know who to report to in the organisation	Competence	Competence	Yes
The HSE procedures cover my work tasks	Rules and procedures	Rules and procedures	yes
Different procedures and routines at different facilities may pose a threat to safety	Rules and procedures	Other	No
I feel sufficiently rested when I'm at work	Competence	Other	No
The equipment I need to carry out my work safety is easily available	Safety systems	Safety systems	Yes
I have easy access to procedures and instructions concerning my work	Rules and procedures	Safety systems	No
Increased cooperation between a facility and land through IT systems has lead to less safety operations	Info	Info	Yes
I feel a group pressure which affects HSE assessments	Other	Other	Yes
I have access to the information necessary to make decisions which ensure the HSE aspect	Info	Info	Yes
Dangerous situations arise because everyone does not speak the same language	Info	Info	Yes
I know which chemicals I may be exposed to	Competence	Competence	Yes
I have been informed of the risks associated with the chemicals I work with	Competence	Competence	Yes
There have been dangerous situations because people have been under the influence of alcohol or drugs at work	Other	Other	Yes

Appendix C

Survey Item Descriptive Statistics Item Descriptive Statistics

Item	*M*	*SD*	*Skew*	*Kurtosis*
Reduced hearing	1.41	.64	1.53	2.23
Ringing in the ears	1.40	.72	1.91	3.12
Headache	1.48	.66	1.22	1.20
Neck/shoulder/arm pain	1.78	.81	.84	.14
Back pain	1.62	.74	1.04	.56
Knee/hip pain	1.53	.75	1.34	1.21
Eye problems	1.23	.50	2.32	5.75
Skin complaints(eczema, rash)	1.41	.68	1.68	2.42
White fingers	1.09	.35	4.54	23.29
Allergic reactions	1.18	.47	2.95	9.39
Stomach/bowel problems	1.32	.60	1.97	3.71
Respiratory problems	1.24	.53	2.40	6.11
Cardiovascular problems	1.04	.23	7.30	64.27
Psychological problems (anxiety, depression, sadness, unease)	1.22	.50	2.43	6.42
Are you exposed to noise levels that are so high that you have to stand close to people and shout to be heard, or have to use headsets?	3.04	1.13	-.23	-.70
Are you exposed to vibrations in your hands or arms from	2.04	1.05	.67	-.47

machines or tools?				
Do you work in cold areas exposed to the weather?	2.88	1.17	-.21	-.87
Are you exposed to a poor indoor climate?	2.45	1.00	.34	-.31
Is your skin exposed to contact with e.g. oil, drilling mud, detergents or other chemicals?	2.34	1.14	.48	-.72
Can you smell chemicals or clearly see the dust or smoke in the air?	2.28	1.07	.48	-.52
Do you do heavy lifting?	2.43	1.07	.19	-.77
Do you do repetitive and monotonous movements?	2.52	1.12	.29	-.78
Do you work in difficult work positions? (e.g. arms above shoulders, bent/twisted back/neck?)	2.64	1.18	.13	-.94
Is it necessary to work very fast?	2.82	.91	-.14	.02
Do you find the shift arrangement a strain?	2.16	1.17	.77	-.30
Do you work so much overtime that it is a strain?	1.66	.81	1.19	1.29
Information about undesirable incidents is used efficiently to prevent recurrences	1.93	.98	1.08	.72
The management takes input from the safety delegates seriously	1.88	.92	1.00	.69
In practice, production takes priority over HSE	2.60	1.31	.231	-1.197
The safety delegates do a good job	1.91	.89	.87	.516
Risk-filled operations are always carefully planned before they are begun	1.37	.65	2.22	6.34
The work permit (WP) system is always adhered to	1.70	.86	1.34	1.83
My supervisor is committed to the HSE work on the facility	1.66	.86	1.31	1.48
Increased cooperation between a facility and land through	2.53	1.06	.00	-.59

IT systems has lead to less safety operations				
Dangerous situations arise because everyone does not speak the same language	2.63	1.32	-.18	-1.26
Defficient maintenance has caused poorer safety	3.12	1.36	-.22	-1.21
At times, I am pressured to work in ways that threaten safety	1.67	1.07	1.51	1.16
My lack of knowledge of new technology may sometimes increase accident risk	1.85	1.10	1.12	.22
I doubt that I will be able to perform my emergency preparedness tasks in an emergency	1.75	.96	1.04	.27
I know which chemicals I may be exposed to	2.05	1.09	1.04	.36
I have been informed of the risks associated with the chemicals I work with	2.05	1.10	.91	-.01
I have access to the information necessary to make decisions which ensure the HSE aspect	1.86	.90	.90	.38
I have been given adequate safety training	1.64	.79	1.48	2.77
I have been given adequate working environment training	1.94	.93	.97	.93
I have the necessary competence to perform my job in a safe manner	1.43	.74	2.30	.74
I am thoroughly familiar with the HSE procedure	1.56	.71	3.43	.71
I have easy access to necessary personal protection equipment	1.26	.65	1.54	.65

Appendix D

Previous Factor Structure (Hoivik, 2009a)

Factor	F1	F2	F3	F4	F5
Safety Prioritisation					
1. Occasionally I'm required to work in a manner that jeopardizes safety	.64				
2. When it comes to one's career it is a disadvantage to be too concerned with HSE	.73				
3. I sometimes violate safety rules to get the job done	.69				
4. My lack of knowledge of new technology can sometimes lead to an increased risk of accidents	.55				
5. I do not participate actively at safety meetings	.36				
6. My work site is often untidy	.45				
7. I find it uncomfortable to call attention to violations of safety rules	.68				
8. The regulatory requirements on HSE are not good enough	.59				
Safety Management and involvement					
1. The company I work for take HSE seriously	.52				
2. My supervisor is committed to working with HSE on the installation	.56				
3. The safety deputies suggestions are taken seriously by the management	.61				
4. Risky work operations are always carefully examined before they are commenced	.39				
5. My colleagues are very preoccupied with HSE	.43				
6. I can influence HSE decisions in my workplace	.48				
7. Information about undesirable incidents are effectively used to prevent them from recurring	.55				
8. The emergency preparedness is good	.56				
9. The safety deputies are doing a good job	.42				
10. It is easy to tell the nurse/company health service about worries and sickness related to the work situation	.48				
11. The work permit system is always lived up to	.48				
Safety Versus Production					
1. Lack of maintenance has resulted in reduced safety		.76			
2. In practice concern for production precedes the concern for HSE		.76			
3. Reports on accidents or dangerous situation are often 'smartened up'		.88			
4. There are often parallel work operations proceeding		.67			

that leads to dangerous situations			
Individual Motivation			
1. I report dangerous situations when I see them	.43		
2. Safety has top priority when I do my job	.41		
3. I stop working if I think it can be dangerous for me to continue	.28		
4. I stop working if I think it can be dangerous for me or other to continue	.28		
5. I use personal protective equipment	.20		
System Comprehension			
1. I think it's easy to find the right steering document		.70	
2. I always know which person within the organization to report to		.62	
3. The HSE procedures are suitable for my work tasks		.69	
Competence			
1. I have the necessary competence to perform my job in a safe manner			.53
2. I have easy access to personal protective equipment			.40
3. I have received sufficient safety training			.61
4. I have received sufficient education when it comes to occupational health and work environment			.53

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