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Exploring the possibility of a common structural model measuring associations between safety climate factors and safety behaviour in health care and the petroleum sectors

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Abstract

The aim of the present study was to explore the possibility of identifying general safety climate concepts in health care and petroleum sectors as well as develop and test the possibility of a common cross-industrial structural model. Self-completion questionnaire surveys were administered in two organisations and sectors: 1) a large regional hospital in Norway that offers a wide range of hospital services and 2) a large petroleum company that produces oil and gas worldwide. In total, 1919 and 1806 questionnaires were returned from the hospital and petroleum organisation, with response rates of 55 percent and 52 percent, respectively. Exploratory factor analysis revealed six identical cross-industrial measurement concepts—five measures of safety climate and one of safety behaviour. The factors' psychometric properties were explored with satisfactory internal consistency and concept validity. Thus, a common cross-industrial structural model was developed and tested using structural equation modelling (SEM). SEM revealed that a cross-industrial structural model could be identified among health care workers and offshore workers in the North Sea. The most significant contributing variables in the model testing stemmed from organisational management support for safety and supervisor/manager expectations and actions promoting safety. These variables indirectly enhanced safety behaviour (stop working in dangerous situations) through transitions and teamwork across units and teamwork within units as well as learning, feedback, and improvement. The results support the possibility of identifying cross-industrial mechanisms concerning the influence of safety climate on safety behaviour despite significantly higher levels of safety climate and safety behaviour in the petroleum sector.

Keywords: Safety climate; Safety culture; Safety management; Occupational safety; Petroleum industry; Health care

1. Introduction

Since *To err is human* was published by the Institute of Medicine in 1999, a system approach has become fundamental to the improvement of patient safety in health care. The tradition of a system approach first emerged in other high hazard industries, such as the energy industry. In this approach, human errors and active failures can be prevented by directing latent system factors. Safety culture has been defined as a key element of system factors (Reason, 1997). In addition, high levels of a "culture of safety" are a key element of high reliability organisations (HROs) (Roberts, 1993; Weick, 1987).

The term *safety culture* was introduced following the Chernobyl accident (IAEA, 1986); since then, the growing interest in safety culture has been accompanied by the need for assessment instruments (Nieva and Sorra, 2003). Several questionnaire instruments have been developed to assess and improve safety cultures in organisations. The resulting data can be used for benchmarking purposes and trend analyses (Mearns et al., 2001). Considerable debate has emerged on the degree to which such instruments measure safety "culture" versus "climate". Safety culture is defined as "the product of individual and group values, attitudes, perceptions, competencies to, and the style and proficiency of, an organization's safety management" (IAEA, 1991, p. 23). Meanwhile, safety climate is regarded "as the surface features of the underlying safety culture [and] assesses workforce perceptions of procedures and behaviours in their work environment that indicate the priority given to safety relative to other organisational goals" (Flin et al., 2006, p. 109). Safety climate has become significant for both practical and theoretical use; furthermore, research suggests that safety climate has the ability to predict safety behaviour and safety-related outcomes (e.g., accidents and injuries) in a wide variety of settings (Y. H. Huang et al., 2007, p. 1089). Safety climate may vary within (D. T. Huang et al., 2007) as well as between organisations (Singer et al., 2003). Research indicates that the safety climate is at lower levels in hospitals compared to the aviation sector (Gaba et al., 2003; Sexton et al., 2000). Still, researchers have not assessed the safety climate level in health care compared to any industries other than aviation.

The primary aim of the current paper is to investigate safety climate questionnaire data based on an assessment of employees in health care and petroleum industries in order to explore the possibility of identifying common safety climate measures across the industries. The data in this study come from two parallel research projects: a patient safety study in a large Norwegian hospital (Thomassen et al., 2005) and a study of a safety program in an international petroleum company headquartered in Norway. Both projects included safety climate assessments, making it possible to conduct a cross-industrial study. Given that common measurement concepts can be identified across industries, the second aim of the paper is to develop and test the possibility of a common cross-industrial structural model. This model will include the measurement concepts developed as a result of the first aim.

1.1 Health care in the Norwegian context

Norway's system of health care provision is based on a decentralised model. Generally speaking, the state is responsible for policy design and overall capacity and quality of health care through budgeting and legislation. In addition, the state is responsible for hospital services through state ownership of regional health authorities. The regional health authorities are organised as health trusts, including somatic and psychiatric hospitals as well as some hospital pharmacies. Regional health authorities and municipalities are formally free to plan and run public health services and social services as they like, within the limits of legislation and available economic resources. Although Norway has a private sector, the Norwegian health care system consists predominantly of hospitals funded by the state (Norwegian Health and Social Services, 2008).

1.2 The petroleum industry on the Norwegian continental shelf

Exploration for oil on the Norwegian continental shelf (NCS) began in the early 1960s; today, the petroleum sector is a major industry in Norway. The authorities grant licenses to produce on the NCS; as a rule, the authorities award production licenses to a group of companies instead of a single company. In this way, companies compete to achieve the licenses, but also cooperate to maximise the value in the production license received. Petroleum companies cooperate with a major supply industry also competing to offer services for petroleum companies that manage the licenses. Likewise, companies in the supply industry must deliver good results to qualify for renewal of contracts. The regulations aim to maximise the values of the NCS, with high considerations for the external environment, health, work environment, and safety (Norwegian Petroleum Directorate and Ministry of Petroleum and Energy, 2008).

1.3 Multilevel perspective on safety climate across industries

Former researchers (Zohar, 2003; Flin, 2007) have suggested a multilevel perspective in the assessment of safety climate in organisations. According to Zohar (2000), a fundamental principle in organisations is that they set their goals and develop strategies to reach these goals. Such goals and strategies consider the changing environment, and top-level management has the first responsibility of defining the appropriate organisational goals and strategies. Meanwhile, middle management is responsible for transforming and developing operating procedures and action guidelines (Zohar, 2000), which is further executed by line managers at the work-group level (Zohar and Luria, 2005) through interactions with subordinates (Zohar, 2000). This multilevel approach emphasises that all levels in the organisation have important safety functions, and some influence performance at the individual level.

Flin (2007) suggests that “safety climate is similar for both patient and worker adverse events” (p. 660). In the development of a safety climate model based on Zohar’s (2007) model, Flin adds patient injury to worker injury as an outcome of safety climate. Flin suggests that her model can be used to assess safety climate in health care. Based on a comparison of safety climate dimensions in health care with those dimensions measured in industry, Flin et al. (2006) conclude: “it seems that at least four ‘core’ dimensions from industry are regarded by researchers as central to the construct of safety climate in healthcare: management commitment to safety, supervisor commitment to safety, safety system and work pressure. […] This lends some weight to the arguments for a set of universal or core variables that underpin safety climate across work sectors, although these probably need to be complemented with sets of specific factors for a particular sector” (p. 662).

Both Zohar’s (2000) and Flin’s (2007) models specify a personal motivational driver between perceived climate and workers’ behaviour. This personal motivation relates to personal expectations of consequences for particular behaviours, which are again interpreted based on safety climate perceptions and the priority of safety at different levels in the organisation. In their study, Griffin and Neals (2000) found that worker knowledge, skill, and motivation mediated the effect of safety climate on safety behaviour. Griffin and Neals (2000) measured knowledge, skill, and motivation at the individual level (e.g. “I understand the health and safety regulations relating to my work”). However, Reason (1997) highlights the importance of creating learning among organisational members. Likewise, Zohar (2000) stresses the importance that different levels in the organisation cooperate on safety policies and practices. Reviews of safety climate studies indicate a great variation in factors assessed as part of safety climate (Flin et al., 2006; Guldenmund, 2000; Zohar, 1980). Measurements of safety climate in health care have more frequently incorporated dimensions related to learning compared with other industries. Hence, no specific line defines what dimensions fall within or outside the safety climate domain (Flin et al., 2006).

Initially, culture and safety climate concepts were developed to explain additional variations in safety-related outcomes (Hale and Hovden, 1998). Zohar (2000) and Flin (2006) specify safety behaviour as an outcome of safety climate and suggest that motivational factors like expectations regarding outcomes mediate this relation. Zohar (2000) suggests that individual worker behaviour is influenced by organisational and group climates via behaviour-outcome expectancies as well as by supervisory safety practices. Zohar's model also specifies that climate at the organisational level influences climate at lower levels; both higher and lower levels of climate affect safety performance at the individual level.

To sum up, safety motivation and behaviour—as well as lower accident levels—can all be expected outcomes of safety climate. The link between safety climate and self-reported safety behaviour has been supported by DeJoy et al. (1995). In addition to safety behaviour, other intra-psychological safety indicators include safety self-efficacy and safety awareness (Huang et al., 2006). Weick and Sutcliffe (2001) emphasise that workers should take the time to stop and resolve unexpected problems as they arise. However, different pressures on production in organisations may reduce workers' mindfulness, which again decrease organisations' ability to manage the unexpected (Weick and Sutcliffe, 2001).

2. Method

2.1 Participants

The hospital and petroleum company surveys started in April 2006 and September 2007, respectively; both lasted approximately six weeks. The target group in the hospital included health workers at the hospital and other personnel employed in the same working environment as the health care personnel. A total of 1919 workers answered the survey at the hospital, resulting in a response rate of 55 percent; of these respondents, 89 percent had direct patient contact, and 62 percent worked between 20 and 37 hours per week. Nurses represented the largest job category (50 percent). Participants' work experience at the hospital included less than one year (6 percent), 1to 5 years (26 percent), 6 to 10 years (21 percent), 11 to 15 (15 percent), 16 to 20 years (11 percent), and 21 years or more (21 percent).

For the petroleum company, the response rate was 52 percent, with 1806 workers answering the survey. Companies in the petroleum sector often use contractors; therefore, this sample also included 296 employees working in 4 different companies under contract for the petroleum company. In the petroleum sample, 44 percent were employed in jobs offshore and 66 percent onshore. The share of workers having an administrative position was higher onshore (59 percent) than offshore (28 percent). The age interval years were categorised as 20 years or younger (1 percent), 21 to 30 years (8 percent), 31 to 40 years (24 percent), 51 to 60 years (36 percent), and 61 years or older (26 percent).

Questionnaires printed in the Norwegian language were distributed to the hospital sample. In the petroleum company, the official working language is English; therefore, the instrument was distributed electronically via e-mail in both an English and Norwegian version so that workers could choose which language in which to respond. In both samples, the respondents answered anonymously.

2.2 Instruments

The data selection was conducted as part of two separate projects. First, the safety climate was surveyed at a large hospital. Second, the safety climate was measured at the petroleum company, opening the possibility for comparing cross-industrial results. At the hospital, the instrument Hospital Survey on Patient Safety Culture (HSOPSC) was used primarily because the dimensionality of HSOPSC covered general topics revealed as part of a broader patient safety project (Thomassen et al., 2005) and because studies have demonstrated that HSOPSC meets more psychometric criteria compared to other instruments (Flin et al., 2006). HSOPSC was originally a generic instrument that measured safety culture and safety climate across health care settings. However, its dimensionality is conventional, measuring many typical dimensions within the theoretical domain in both health care and other industries (Flin et al., 2006). According to Sorra and Nieva (personal communication), who developed HSOPSC, the theoretical basis for the development of the instrument was inspired by and based on safety climate theory developed by Zohar (1980). All items in HSOPSC are rated on Likert-type scales with verbal anchors. The number of events reported (during the previous 12 months) is measured on a scale from 1 to 6; all other concepts are measured on scales from 1 to 5. More details about HSOPSC are provided at www.ahrq.gov/qual/hospculture.

As part of the patient safety project, HSOPSC was validated using the hospital data before distribution to the petroleum sample. The results indicated that the factorial model fitted the data well, and the psychometric properties of the instrument were considered satisfactory (Olsen, 2008).

When planning to measure safety climate in the petroleum industry, the general idea was to develop an instrument that—as much as possible—would have the same measurement concepts as HSOPSC. Since HSOPSC consists of 10 safety climate dimensions that are quite general, this was considered a possible alternative. It is however quit clear that safety challenges in high risk industries can be significantly different from those in health care (Vincent, 2006).

The original version of HSOPSC was translated into Norwegian before distribution in the hospital (Olsen, 2008). There was some concern that not all items in HSOPSC were appropriate for use in the petroleum context. Experts in the participating petroleum company were therefore involved to ensure that HSOPSC items were made relevant to the petroleum context. Still, the goal was still not to do more than necessary changes on items.

Accordingly, a few adaptations of the instrument were made before distribution to the petroleum sample. One issue was the term *patient*, which was removed from certain items; for example, the original item “my supervisor/manager seriously considers staff suggestions for improving patient safety” was changed to “my supervisor/manager seriously considers staff suggestions for improving safety” before the instrument was distributed to the petroleum sample. Still, for many of the items there was no need for any revision as the meaning generally relates to cross-industrial settings. One example is items measuring teamwork (e.g., “People support one another in this unit”), which tend to be general and not specific to patient safety and can therefore be used across industries.

After meeting with safety experts in the petroleum company, nine items were removed in order to trim the original version of HSOPSC. Among other outcomes, this resulted in removing the criterion measure overall perceptions of safety. To compensate, a new criterion measure for the likelihood that an employee would stop working in dangerous situations was added. This measure was already included in the questionnaire distributed in the hospital. The dimension “stop working in dangerous situations” consists of three items measured on a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neither, 4=agree, 5=strongly agree): 1) I ask my colleagues to stop work that is dangerously accomplished, 2) I notify if I see dangerous situations; and 3) I stop working if I consider the situation to be dangerous for me or my colleagues.

After these adaptations to the questionnaire, a total of 37 items measured on Likert scales were used to analyse safety climate in both sectors.

2.3 Statistical procedures

With the exception of the structural equation modelling (SEM), statistical analysis was conducted using SPSS 15.0. The "don't know" category added to 7 items was treated as missing values before any of the analyses were conducted. Mean scores for the dimensions were created after development of the final factor structure and after reversing the coding for the reverse items. SEM, performed by AMOS 7, was employed to examine the hypothetical structural model. Testing of the structural model was separated according to major categories in both the hospital (nurses versus non-nurses) and petroleum sample (onshore versus offshore).

To determine if factor scales yielded acceptable alpha coefficients and internal consistency, Cronbach's alpha was estimated. Multiple Analysis of Variance (MANOVA) was used to test whether an overall difference in employee perceptions of safety climate and safety behaviour existed. T-test statistics were estimated to determine if the mean differences were significant for each measurement concept. Pearson's r was estimated separately for each sector to investigate correlations between concepts.

3. Results

3.1 Development of measurement concepts

Since HSOPSC was trimmed and some adaptations were made before the instrument was distributed to the petroleum sample, it was necessary to ensure concepts' validity after the changes. Thus, an exploratory factor analysis (EFA) was conducted using a separated analysis for both industries. As loadings above .50 are generally considered "very significant" (Hair et al., 1998), this served as one criterion. Other criteria included the fact that factors should have more than one substantial loading; more than 5 percent of the variance should be attributed to the factor, and as a general guide eigenvalues were set to be more than 1. In addition, common sense should be used as a guide in deciding in the number of factors to extract (Netemeyer et al., 2003). As the aim of the EFA was to explore the possibility of identifying general safety climate concepts in both health care and the petroleum sector, items were removed from analysis in both sectors if they had a poor fit to the various criteria used.

The final factor solution resulted in a common six-factor cross-industrial model (see Tables 1 and 2). The first factor was labelled learning, feedback, and improvement and comprises five items measuring learning, feedback, and improvement at the department level. With the exception of one item, all items for this factor were identically measured in both industries. The second factor was labelled teamwork within units and consists of four items concerning teamwork within units; in addition, the items for the second factor were identical for both industries. The third factor was labelled supervisor/manager expectations and actions promoting safety; this factor consisted of four items concerning safety leadership at the unit level. The major differences between industries for the third factor are that the term *patient* was removed from the petroleum survey. The fourth and fifth factors were exchanged for the different industries on the rotated factor solution. For the petroleum sample, the fourth factor was labelled stop working in dangerous situations; it comprised three items concerning workers' safety behaviour and their decision to stop working in dangerous situations. The fourth factor on the petroleum sample was identical to the fifth factor on the hospital sample. The fifth factor on the petroleum sample was labelled transitions and teamwork across units and included three items. This factor was the fourth factor on the hospital sample, with slightly different wordings used without the term *patient*. The sixth factor was labelled organisational management support for safety, consisting of 2 items concerning this topic.

The factor solution revealed six common cross-industrial factors. During the EFA process, the instrument was trimmed from 37 to 21 items—three at the department/unit level (supervisor/manager expectations and actions promoting safety; learning, feedback, and improvement; and teamwork within units), two at the organisational level (organisational management support for safety and transitions and teamwork across units), and one at the individual level (measuring a particular type of safety behaviour: stop working in dangerous situations).

The same factors were also reviewed on major subsamples in both the health care (nurse background versus other occupations) and petroleum samples (onshore workers versus offshore workers), supporting the robustness of the measurement structure. Since the factor solution developed is based on and has some common dimensions as HSOPSC, the measurement tool illustrated in Table 1 is labelled HSOPSC-short. Table 2 illustrates that the same measurements can be used in industries other than health care after some small adjustments. The factor model illustrated in Table 2 is labelled Short Safety Climate Survey (SSCS), indicating that it is a more generic safety climate instrument than the HSOPSC-short, which is more clearly aimed at workers in a health care setting.

Tables 1 and 2 about here

3.2 Internal consistency

Cronbach's alpha was estimated for both samples; the results are shown in Table 3. The alpha scores range from .72 to .82 in the petroleum sample and from .63 to .78 in the hospital sample. In the petroleum sample, the lowest alpha score is estimated for the dimension measuring transitions and teamwork across units (.72). Stop working in dangerous situations (.63) had the lowest score in the hospital sample. As the Cronbach's alpha value of each factor is greater than 0.6, the questionnaire's internal consistency and reliability should be considered adequate (Nunnally, 1978).

Table 3 about here

3.3 Correlations

Pearson's *r* was estimated to examine the discriminant validity among measures. As the associations between measures could be expected to vary between industries, the correlations were separated between the sectors (see Tables 4 and 5). Although the strength of the correlations varies somewhat between the industries, the associations are quite comparable in strength. In the hospital sample, correlations vary between .17 and .52 ($p < .01$ level, two-tailed), while the variation ranges from .26 to 47 ($p < .01$ level, two-tailed) in the petroleum sample.

Tables 4 and 5 about here

3.4 Test of differences between samples

MANOVA and t-test statistics were determined to investigate the differences of measurement concepts between workers in health care and petroleum industries. The MANOVA revealed an overall difference between the two industries when the six dimensions were used as dependent variables and the industries were defined as the dichotomised (hospital vs. petroleum) independent variable: Wilks' Lambda of 0.704 (df=6), p <0.001, effect size=0.296 (Eta2). Hence, results generally indicate different scorings between the industries.

The mean differences and t-tests are provided in Table 6. These analyses provide added information to MANOVA as the t-tests estimate if the differences between sectors are significantly different for each measurement concept. The t-test analyses indicate that the factor levels are significantly higher in the petroleum sample for all six concepts compared with health care. The differences between the mean scores are highest for the dimension organisational management support for safety (0.98) and supervisor/manager expectations and actions promoting safety (0.33). With two exceptions (organizational management support for safety and supervisor/manager expectations and actions promoting safety), the level on the dimensions is higher among offshore than onshore personnel in the petroleum sample. Four significant differences is observed between nurses versus other job categories in the health care sample. With the exception of organizational management support for safety, nurses scored significantly higher on these dimensions (stop working in dangerous situations, supervisor/manager expectations and actions promoting safety, teamwork within units).

Table 6 about here

3.5 Modelling safety climate factors' influence on individual safety performance

Zohar (2000) developed a multilevel safety climate model that Flin (2007) further adapted to fit the health care context. However, cross-industrial research aimed at developing and testing cross-industrial safety climate models—one of the aims of the current study—has been lacking.

The general model assumption in the following discussion is that top-level management is primarily responsible for defining the correct goals and strategies for the organisation and signalling the relative importance of safety (including patient safety in health care settings) towards other organisational goals. In doing so, top-level management will enhance the safety priority in the organisation by influencing lower level supervisors and increasing transitions and teamwork across units. Likewise, by promoting safety at the unit level, supervisors will likely be able to influence transitions and teamwork across units, expecting high levels of quality in coordination and transitions among units.

Supervisor/manager expectations and actions promoting safety are generally believed to have a significant influence on safety climate at the unit level (Zohar and Luria, 2003). Thus, higher levels of supervision at the unit level will likely influence two unit level variables: 1) teamwork within units and 2) learning, feedback, and improvement within units. It is also reasonable to believe that teamwork within units and learning, feedback, and improvement within units will benefit from higher levels of transitions and teamwork across units.

High levels of learning, feedback, and improvement at the unit level will inspire work groups so that teamwork at the unit level will be enhanced. High levels of learning, feedback, and improvement at the unit level will also improve safety behaviour directly due to the learning processes. Likewise, higher levels of teamwork at the unit level will enhance safety behaviour. It is further assumed that the safety climate level variables at the unit level will mediate the effects of supervisors at the unit level as well as transitions and teamwork across units and indirectly affect influence from organisational management support for safety.

Hypothesis 1: Organisational management support for safety will enhance safety behaviour first via 1) supervisor/manager expectations and actions promoting safety and transitions and 2) transitions and teamwork across units and subsequently via group climate variables—namely, teamwork within units and learning, feedback, and improvement.

Hypothesis 2: A higher level of supervisor/manager expectations and actions promoting safety and transitions at the unit level will directly enhance 1) teamwork within units and 2) learning, feedback, and improvement.

Hypothesis 3: Supervisor/manager expectations and actions promoting safety will also enhance teamwork within units and learning, feedback, and improvement as well as indirectly enhance teamwork through transitions and teamwork across units.

Hypothesis 4: A higher level of learning, feedback, and improvement will enhance safety behaviour directly through teamwork within units.

Hypothesis 5: A higher level of transitions and teamwork across units will enhance safety behaviour through 1) teamwork within units and 2) learning, feedback, and improvement.

Hypothesis 6: A higher level of teamwork within units will enhance safety behaviour.

Figure 1 about here

3.6 Testing of structural model

SEM was conducted to test the hypotheses depicted in Figure 1. Due to the possibility of inter-group differences, SEM was first separated between major groups in both the health care and petroleum samples. In the health care sample, this grouping was divided between nurses versus the sum of all other occupations. In the petroleum sample, the grouping was divided between onshore and offshore workers.

The overall fit among nurses was assessed by $\chi 2$ f(200)=581, $p < .001$. It is common to use the Satorra-Bentler scaled $\chi 2$ to evaluate model fit. However, the problem with $\chi 2$ is that it is directly related to sample size; as such, almost all models are evaluated as incorrect as sample size increases (Bentler and Bonnet, 1980). Due to the relatively large sample size in the current study, $\chi 2$ was not used to evaluate model fit. Generally, the fit indices were satisfactory (RMSEA=0.045, NFI=0.91, IFI=94, CFI=0.94). All hypothesised influences were supported in the model. This result—together with satisfactory fit indices—indicates an adequate model among nurses.

The overall fit among other personnel in health care (other than nurses) was assessed by $\chi 2$ f(200)=745, $p < .001$. Generally, the fit indices indicated an acceptable model (RMSEA=0.053, NFI=0.88, IFI=91, CFI=0.91). All hypothesised influences were supported in the model. This result—together with acceptable fit indices—indicates an adequate model among personnel other than nurses in health care. Along with testing among nurses, this result indicates that the model can be generalised across hospital settings. To test this result, the model was assessed on the total hospital sample: $\chi 2$ f(200)=1112, $p < .001$. Generally, the fit indices indicated an acceptable model (RMSEA=0.049, NFI=0.91, IFI=93, CFI=0.93). All hypothesised influences were supported in the model. Thus, along with satisfactory fit indices, this result indicates an adequate model among health care workers in general.

The overall fit among offshore workers in the petroleum sample was assessed by $\chi 2$ f(200)=845, $p < .001$. Generally, the fit indices indicated an acceptable model (RMSEA=0.063, NFI=0.87, IFI=90, CFI=0.90). All hypothesised influences were supported in the model. This result, together with acceptable fit indices, indicates an adequate model among offshore workers.

Meanwhile, the overall fit among onshore workers in the petroleum sample was assessed by $\chi 2$ f(200)=1447, $p < .001$. With the exception of RMSEA indices, the fit indices did not indicate an acceptable model (RMSEA=0.079, NFI=0.84, IFI=0.86, CFI=0.86). The results do not indicate an adequate model among onshore personnel in the petroleum sample; therefore, the model was not assessed on the total petroleum sample.

The standardised path coefficients on the total hospital sample are presented in Figure 2 while the offshore petroleum sample is presented in Figure 3. As expected, in the specified hypothesis, path coefficients in the figures generally indicate support for the specified hypothesis, indicating significant positive associations between concepts. In both figures, paths from organisational management support for safety and supervisor/manager expectations and actions promoting safety differ from the other paths with higher coefficients. Thus, the results support the importance of both high-level management support for safety and lower-lever supervision to the other climate concepts and, ultimately, to the level of safety behaviour. Furthermore, learning, feedback, and improvement are important in both figures due to the contributions to both teamwork and safety behaviour. At the intermediate level, transitions and teamwork across units significantly enhance learning, feedback and improvement as well as teamwork at the unit level. This result indicates that transitions and teamwork across units have important—albeit indirect—functions on safety behaviour.

Figures 2 and 3 about here

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5. Discussion

The first aim of the present study was to explore the possibility of identifying safety climate concepts across health care and petroleum sectors. During the EFA process, the number of dimensions was reduced from the original version of HSOPSC; two of the dimensions (hospital handoffs and transitions; teamwork across hospital units) on the organisational level were merged into transitions and teamwork across units. Likewise, EFA resulted in a merging of two of the dimensions at the unit level (organisational learning—continuous improvement; feedback and communication about error) into learning, feedback, and improvement. Two other dimensions from HSOPSC, non-punitive response to error and staffing, were also removed in the EFA process. The measures developed are clearly related and partly overlapping with the original concepts in HSOPSC. Both merged dimensions are theoretically overlapping, justifying that common factors can be identified. The results further revealed that a factor structure with five common safety climate dimensions and one safety behaviour measure can be acknowledged across sectors.

The factors developed on the basis of workers in health care are clearly comparable to the factors developed in regards to workers in the petroleum sector. For example, in the factor learning, feedback, and improvement, four out of five items are identical for both samples. Furthermore, all teamwork items are identical. Only the term *patient* has been removed from items measuring supervisor/manager expectations and actions promoting safety, although all three items are identical across sectors for the concept of stopping work in dangerous situations. The factor transitions and teamwork across units utilises slightly different wording (i.e., without the term *patient*) in the petroleum survey. Instead of referring to the hospital management emphasis on patient safety, organisational management support for safety measures this phenomenon in general in petroleum, without the term *patient*. However, it is important to recognise that some dimensions in the HSOPSC-short more clearly address patient safety than dimensions in SSCS. Slightly different wordings on the instruments used for the different sectors would suggest higher probability for not replicating similar and comparable latent factors. Instead, the results indicate a robust factorial structure across sectors and generally support the assumption made by Flin (2007)—namely, that safety climate may be similar for both patient and worker safety.

Generally speaking, the investigation of psychometric properties of the factors supports the internal consistency and validity of the measurement concepts; correlations in both samples are moderately associated between the dimensions, indicating discriminant validity of measures. Significant differences between health care and petroleum workers also support the discriminant validity of measurement concepts. Results from the SEM indicate satisfactory concurrent validity of concepts and strengthen the impression of satisfactory concept validity. These combined results give the impression that psychometric properties of measurements are satisfactory across the two sectors investigated.

Given that common measurement concepts could be identified across industries, the second aim of this paper was to develop and test the possibility of a common cross-industrial structural model. This testing was first tested on nurses versus the sum of other occupations. Results revealed satisfactory model fit in both of these subsamples. Consequently, it is reasonable to believe that the model could be generalised across subsamples in health care—an assumption supported by the data. SEM revealed that the model fitted the overall health care sample well and that all hypothesised paths were significantly supported. However, in the petroleum sample, the model only resulted in a satisfactory fit with offshore workers, but not with the onshore subsample of petroleum workers. Hence, the results indicate that a cross-industrial structural model can be generalised between health care and petroleum sectors, but it is limited to offshore workers. Among these workers, organisational management's support for safety and supervisor/manager expectations and actions promoting safety play a significant role in regards to other climate concepts and, indirectly, on the level on safety behaviour. In addition, learning, feedback, and improvement at the unit level are important in both sectors because of the contributions they make to both teamwork within units and safety behaviour. Another common mechanism at the intermediate level is that transitions and teamwork across units significantly enhance learning, feedback, and improvement as well as teamwork at the unit level, further demonstrating that transitions and teamwork across units indirectly affect safety behaviour.

The similarity of path coefficients and satisfactory fit indices generally support the conclusion that a common model can be developed among health care and offshore petroleum workers. However, interestingly, the same model cannot be replicated among onshore petroleum workers. One can only speculate why the model did not fit with onshore petroleum workers. This group has a large share of administrative work characteristics among its workers and may differ from offshore and health care workers in this manner. Another explanation is that other dynamics better explain the relation between organisational factors and safety behaviour among onshore workers.

The model testing supported the basic principle in Zohar's multilevel safety climate model—namely, upper level management significantly influences organisations when it comes to putting safety on the agenda, integrating it into policies and practice, and ensuring that lower-level management and supervisors execute these in practice. Path estimation for both hospital workers and offshore petroleum workers supported the positive influence of high-level management. In addition, the results suggest that both high-level management and lower-level supervisors can contribute toward and enhance transitions and teamwork across units. Both Zohar (2000) and Flin (2007) suggested that managers' prioritisation of safety will influence workers' motivation and signal that safety is an expected value that should guide behaviour. Among both health care and offshore workers, the results from the current study clearly indicated the importance of management and supervision towards safety and of transitions and teamwork across units. These factors considerably enhance teamwork in units as well as learning, feedback, and improvement in units and indirectly affect safety behaviour for the individual worker.

In sum, the results from the development of measurement concepts and testing of the structural model justify some kind of further comparison between sectors. The results from MANOVA indicate an overall different level of safety climate and safety behaviour between the two sectors. T-test statistics further explored the differences, indicating higher levels for all measures among petroleum workers.

The positive associations between safety climate and safety behaviour support the importance of safety climate for organisational safety (Johnson, 2007). Results from the current study also supported previous studies indicating that the safety climate level in the health care sector is lower than in other high hazard industries like aviation (Gaba, 2003; Sexton et al., 2000). The present study supports the importance of safety climate and the conclusion that a higher level of safety climate is positively associated with workers stopping their work in dangerous situations. Hence, the results address two important questions: Why is the safety climate level generally lower in health care compared with the petroleum industry, and what should be done in order to improve the safety climate level in health care?

Various explanations address why the level of safety climate dimensions is generally lower in health care compared with petroleum in the current study. Most notably, the differences between the industries are related to the different safety traditions within the two sectors. During the 1980s, the petroleum industry implemented great changes with new technology, committed leadership, and employee participation. During the 1990s, attention shifted to safety management systems, which were followed up with the continued improvement of safety culture after 2000 (Haukelid, 2008). The drive for improved patient safety in modern health care started in the United States with *To err is human* in 1999 (Institute of Medicine). The relatively short history of patient safety makes it reasonable to assume that many efforts to improve patient safety remain untried in Norwegian health care. For example, national safety programs have not yet been implemented to improve patient safety.

The increased drive for improving safety in the petroleum industry over the last decades can be due to many factors. First, the risk in many subgroups in the petroleum industry involves direct risk for the worker (e.g., if a platform explodes). Although health care workers to some degree are exposed to risk (e.g., HIV/AIDS and other blood-borne pathogens) (DeJoy et al., 1995), it may be that the perceived risk of health care workers in general is lower than that of offshore petroleum personnel. This may lead to a lower personal interest and motivation for improving safety among health care workers. Indeed, in the petroleum industry, safety has become an important trademark. The slogan “safety first” is commonly used. In addition, safety records have a competitive value in the distribution of licenses and the selection of contractor companies in distributing contracts.

The petroleum company examined in the current study has for many years strived to improve its safety culture and safety behaviour. For example, a large-scale safety program focused on implementing five barriers in the organisation in order to improve safety: 1) taking the time needed to work safely (correct prioritisation), 2) being loyal to procedures, requirements, guidelines, and decisions (compliance), 3) being open to discuss safety with line management at any level as well as with colleagues (open dialogue), 4) taking the time to evaluate what kind of accidents can happen if something unexpected occurs (continuous risk assessment), and 5) taking care of yourself and your colleagues when you when you observe risk (caring) (Olsen et al., in press). Prior to this specific safety program, other safety interventions in the company stressed the importance of telling others of potentially dangerous matters (Johannessen and Olsen, 2004) and making workers aware of how they can personally influence safety (Olsen and Johannessen, 2004). The different safety activities here are only some examples of time, effort, and resources used to improve safety. Although the effect of each intervention is hard to prove, these examples might give some additional explanation for the higher level of safety climate and safety behaviour in the petroleum company.

Undoubtedly, no simple answer exists in regards to how to improve safety climate in health care. It has taken the petroleum industry decades to develop its current safety level, implying that the improvement of safety in health care will take time as well. However, the correct solution is not too uncritically copy solutions from other high hazard industries, especially since classification of adverse events in health care has particular characteristics (Tamuz and Thomas, 2006). Still, worker safety is positively associated with safety climate (DeJoy et al., 1995) and management practices (Vredenburgh, 2002) in health care settings. Likewise, safety climate has been positively associated with the grading of patient safety level by workers in health care (Sorra and Nieva, 2004). These studies make it important to look at historical and cultural precedents that may prevent health care from becoming an ultra safe system.

Amalberti et al. (2005) have defined five specific needs in order to improve systems' safety in health care: 1) the need to limit the discretion of workers, 2) the need to reduce worker autonomy, 3) the need to make the transition from a craftsmanship mindset to that of equivalent actors, 4) the need for system-level (senior leadership) arbitration to optimise safety strategies, and 5) the need for simplification. These ingredients have generally been addressed in the petroleum company investigated in this study as part of its safety improvement efforts (Olsen and Johannessen, 2004; Olsen et al., in press). Furthermore, Amalberti et al. (2005) emphasise the importance of overcoming unique problems in health care—handling both the wide range of risk and the difficulty in defining medical error—and the importance of addressing various structural constraints that hamper patient safety efforts (p. 756). Research has indicated that safety climate can be considerably improved in two years (Tharaldsen et al., 2007). If Amalberti et al.'s (2005) suggestions are taken seriously, it is reasonable to believe that incremental changes over time can improve the levels of safety climate and safety outcomes in health care.

This study has certain limitations. First, the health care industry is only represented by one hospital in this study—albeit a large regional hospital with a wide range of services. Earlier research has shown that the safety climate may vary between organisations (Singer et al., 2003). It may well be that the samples in the current study do not represent the two sectors in general; therefore, more research will be needed to further address the research questions explored in this study. Moreover, all components assessed with SEM are measured using the same questionnaire; therefore associations are not proven over time. It would have been interesting to correlate the measurement in this study with other types of outcome variables, such as accident statistics. The results in this study can meaningfully be supplemented with a qualitative approach investigating the relation between safety climate factors and specific contexts in health care and the petroleum industry. It is important to emphasise that the safety climate factors investigated in this study are not exhaustive to what may have been included within the safety climate approach. This point has been thoroughly illustrated in former reviews of safety climate (Flin et al., 2000; Flin et al., 2006; Guldenmund, 2000; Singla et al., 2006; Colla et al., 2006).

6. Conclusion

This study investigated the possibility of developing a common measurement and structural model across large industries—namely, the health care sector and the petroleum industry. The research discussed herein generally supports this possibility; although some small differences existed between measurement concepts, the same latent measurement structure was identified across industries and some major subsamples. This outcome provided the possibility of developing and assessing a common structural model across industries. The results support the possibility of a common structural model among health care workers and offshore petroleum workers; however, the model did not satisfactorily fit onshore petroleum workers.

The structural model illustrates the importance of a multilevel approach towards a satisfactory safety level. Such an approach should include safety commitments at all levels and a high level of specific factors—namely, 1) organisational management support for safety; 2) transitions and teamwork across units; 3) supervisor/manager expectations and actions promoting safety; 4) teamwork within units; and 5) learning, feedback, and improvement. According to the results of the current study, high levels of such dimensions will result in a higher level on safety behaviour (i.e., workers stop working in dangerous situations) in the health care sector and among offshore petroleum workers.

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Table 1. Factor analysis based on the hospital sample (HSOPSC-short)

	Factor loadings					
Items	1	2	3	4	5	6
We are informed about errors that happen in this unit	**0.76**	0.11	0.13	0.03	0.10	0.08
In this unit. we discuss ways to prevent errors from happening again	**0.74**	0.16	0.32	0.07	0.07	0.06
Staff feel free to question the decisions or actions of those with more authority	**0.66**	0.14	0.32	0.12	0.10	-0.03
We are given feedback about changes put into place based on event reports	**0.65**	-0.01	0.07	0.04	-0.01	0.18
Staff feel free to question the decisions or actions of those with more authority	**0.62**	0.30	0.08	0.05	0.21	-0.03
People support one another in this unit	0.12	**0.80**	0.19	0.06	0.01	0.04
In this unit. people treat each other with respect	0.08	**0.79**	0.18	0.06	0.09	0.04
When a lot of work needs to be done quickly. we work together as a team to get the work done	0.10	**0.70**	0.19	0.08	0.08	0.14
When one area in this unit gets really busy. others help out	0.21	**0.62**	0.03	0.08	0.19	0.02
My supervisor/manager overlooks patient safety problems that happen over and over (r)	0.19	0.13	**0.73**	0.08	0.08	0.10
My supervisor/manager seriously considers staff suggestions for improving patient safety	0.29	0.27	**0.73**	0.07	0.01	0.06
My supervisor/manager says a good word when he/she sees a job done according to established patient safety procedures	0.25	0.24	**0.67**	0.03	0.09	0.01
Whenever pressure builds up. my supervisor/manager wants us to work faster. even if it means taking shortcuts	0.08	0.05	**0.67**	0.06	0.12	0.19
Problems often occur in the exchange of information across hospital units (r)	0.07	0.10	0.03	**0.84**	0.03	0.06
It is often unpleasant to work with staff from other hospital units (r)	0.08	0.13	0.04	**0.75**	0.04	0.09
Things “fall between the cracks” when transferring patients from one unit to another (r)	0.04	0.01	0.11	**0.69**	0.08	0.15
I notify if I see dangerous situations	0.17	0.13	0.06	0.01	**0.80**	0.07
I ask my colleagues to stop work that is dangerously accomplished	0.10	0.07	0.02	0.08	**0.79**	0.02
I stop working if I consider the situations to be dangerous for me or my colleagues	0.05	0.11	0.36	0.07	**0.55**	0.02
The actions of hospital management show that patient safety is a top priority [b]	0.11	0.07	0.15	0.15	0.03	**0.87**
Hospital management provides a work climate that promotes patient safety [b]	0.12	0.13	0.14	0.18	0.07	**0.84**
Explained variance	12.84	11.95	11.86	8.86	8.29	7.67

Principal Component Analysis with Varimax rotation. Rotation converged in 6 iterations.
r: Negatively formulated item. [a] Item is measured on the following scale: 1=never, 2=rarely, 3=sometimes, 4=most of the time, 5=always. The remaining of items is measured on the following scale: 1=strongly disagree, 2=disagree, 3=neither, 4=agree, 5=strongly agree. [b]: A “don’t know” response category was added to this items’ response scale; relatively few responses was however given on this response option.

Table 2. Factor analysis based on petroleum sample (SSCS)

Items	Factor loadings 1	2	3	4	5	6
We are given feedback about changes put into place based on event reports [a]	**0.77**	0.03	0.02	0.08	0.13	0.13
We are informed about errors that happen in this unit [a]	**0.75**	0.06	0.13	0.17	0.14	-0.06
In this unit. we discuss ways to prevent errors from happening again [a]	**0.73**	0.20	0.15	0.18	0.08	0.12
Staff will freely speak up if they see something that may negatively affect safety [a]	**0.63**	0.19	0.16	0.25	0.06	0.06
Staff feel free to question the decisions or actions of those with more authority [a]	**0.56**	0.28	0.13	0.09	0.03	0.09
People support one another in this unit	0.13	**0.81**	0.18	0.12	0.06	0.12
In this unit. people treat each other with respect	0.08	**0.79**	0.18	0.14	0.09	0.14
When a lot of work needs to be done quickly. we work together as a team to get the work done	0.24	**0.65**	0.02	0.25	0.14	0.01
When one area in this unit gets really busy. others help out	0.18	**0.61**	-0.03	0.12	0.19	-0.02
My supervisor/manager overlooks safety problems. even though they happen again and again (r)	0.06	0.00	**0.82**	0.13	0.15	0.11
Sometimes my supervisor/manager wants me to work faster. even if it means taking shortcuts (r)	0.09	0.04	**0.82**	0.12	0.14	-0.01
My supervisor/manager seriously considers staff suggestions for improving safety	0.34	0.31	**0.58**	-0.02	-0.01	0.25
My supervisor/manager says a good word when he/she sees a job done according to established safety procedures	0.32	0.30	**0.57**	0.02	0.04	0.19
I stop working if I consider the situations to be dangerous for me or my colleagues	0.20	0.14	0.12	**0.82**	0.08	0.04
I notify if I see dangerous situations	0.26	0.16	0.07	**0.81**	0.06	0.09
I ask my colleagues to stop work that is dangerously accomplished	0.14	0.24	0.07	**0.74**	0.07	0.05
Problems often occur in the exchange of information across units (r)	0.13	0.13	0.09	0.06	**0.82**	0.10
Things "fall between the cracks" when transferring information from one unit to another (r)	0.12	0.04	0.12	0.10	**0.80**	0.12
It is often unpleasant to work with staff from other units (r)	0.07	0.20	0.07	0.03	**0.66**	0.05
The actions of the corporate management show that safety is a top priority [b]	0.09	0.09	0.12	0.09	0.14	**0.88**
The management (in Statoil) provides a work climate that promotes safety [b]	0.14	0.10	0.16	0.07	0.13	**0.87**
Explained variance	13. 94	12.40	10.69	10.43	9.36	8.40

Principal Component Analysis with Varimax rotation. Rotation converged in 6 iterations. r: Negatively formulated item. [a] Item is measured on the following scale: 1=never, 2=rarely, 3=sometimes, 4=most of the time, 5=always. The remaining of items is measured on the following scale: 1=strongly disagree, 2=disagree, 3=neither, 4=agree, 5=strongly agree. [b]: A “don't know” response category was added to this items' response scale; relatively few responses was however given on this response option.

Table 3: Internal consistency of measures

Measures	Number of items in scale	Alpha	
		Petroleum	Hospital
Dimension—safety behaviour			
Stop working in dangerous situations	3	.80	.63
Dimensions—unit level			
Supervisor/manager expectations and actions promoting safety	4	.77	.77
Learning, feedback and improvement	5	.79	.78
Teamwork within units	4	.78	.77
Dimensions—organizational level			
Organizational management support for safety	2	.82	.78
Transitions and teamwork across units	3	.72	.66

Table 4: Pearson correlations between measurement concepts in the hospital sample.

Variable	1.	2.	3.	4.	5.	6.
1. Stop working in dangerous situations	-					
2. Supervisor/manager expectations and actions promoting safety	.32	-				
3. Learning, feedback and improvement	.31	.52	-			
4. Teamwork within hospital units	.30	.43	.40	-		
5. Organizational management support for safety	.16	.33	.28	.23	-	
6. Transitions and teamwork across units	.17	.22	.21	.24	.33	-

All correlations are significant at the $p<.01$ level.

Table 5: Pearson correlations between measurement concepts in the petroleum sample.

Variable	1.	2.	3.	4.	5.	6.
1. Stop working in dangerous situations	-					
2. Supervisor/manager expectations and actions promoting safety	.30	-				
3. Learning, feedback and improvement	.47	.41	-			
4. Teamwork within units	.43	.38	.44	-		
5. Organizational management support for safety	.20	.37	.27	.27	-	
6. Transitions and teamwork across units	.23	.29	.28	.29	.26	-

All correlations are significant at the p<.01 level.

Table 6: Descriptive statistics for sub-samples and difference comparison for health care and petroleum sample (standardized scores).

	Petroleum						Hospital							
	Onshore		Offshore		Total petroleum sample		Nurses		Other than nurses		Total hospital sample		Total petroleum sample —Total hospital sample	
Dimension—safety behaviour	Mean	St.d.	Mean	St.d.	Mean	St.d.	Mean	St.d.	Mean	St.d.	Mean	St.d.	Mean diff.	Sig.
Stop working in dangerous situations	4.07	0.55	4.23[a]	0.52	4.14	0.55	**3.96**	0.53	3.84[A]	0.59	3.90	0.57	0.24	***
Dimensions—unit level														
Supervisor/manager expectations and actions promoting safety	4.19	0.61	4.12[c]	0.64	4.16	0.62	**3.86**	0.67	3.78[C]	0.68	3.82	0.68	0.33	***
Learning, feedback and improvement	3.56	0.70	3.85[a]	0.52	3.69	0.64	3.37	0.67	3.32	0.69	3.42	0.67	0.27	***
Teamwork within units	3.87	0.59	3.94[b]	0.55	3.90	0.57	**3.93**	0.57	3.75[A]	0.62	3.84	0.60	0.06	**
Dimensions—organizational level														
Organizational management support for safety	3.98	0.70	3.63[a]	0.83	3.83	0.78	**2.75**	0.82	2.95[A]	0.80	2.85	0.82	0.98	***
Transitions and teamwork across units	3.34	0.69	3.49[a]	0.65	3.40	0.67	3.00	0.53	2.99	0.59	3.14	0.60	0.27	***

* Significant difference between petroleum and hospital sample ($p < .05$). ** Significant difference between petroleum and hospital sample ($p < .01$). *** Significant difference between petroleum and hospital sample ($p < .001$). a: Significant difference between onshore and offshore ($p < .001$). b: Significant difference between onshore and offshore ($p < .01$). c: Significant difference between onshore and offshore ($p < .05$). A: Significant difference between nurses and other job categories ($p < .001$). B: Significant difference between nurses and other job categories ($p < .01$). C: Significant difference between nurses and other job categories ($p < .05$).

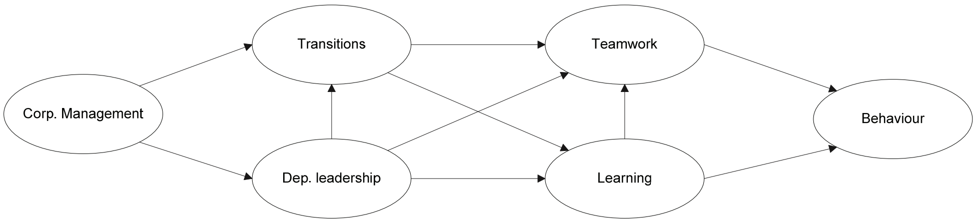

Fig. 1. The hypothetical model of the present research. *Note*: corp. management=organizational management support for safety; transitions=transitions and teamwork across units; dep. leadership=supervisor/manager expectations and actions promoting safety; teamwork=teamwork within units; learning=learning, feedback and improvement; behaviour=stop working in dangerous situations.

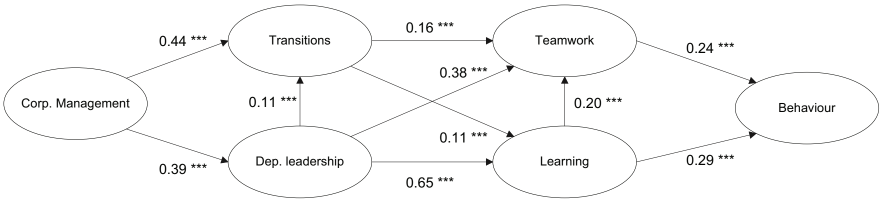

Fig. 2. Structural model tested on health care workers with standardized path coefficients. *Note*: corp. management=organizational management support for safety; transitions=transitions and teamwork across units; dep. leadership=supervisor/manager expectations and actions promoting safety; teamwork=teamwork within units; learning=learning, feedback and improvement; behaviour=stop working in dangerous situations. All paths are significant: * $p < .05$, ** $p < .01$, *** $p < .001$

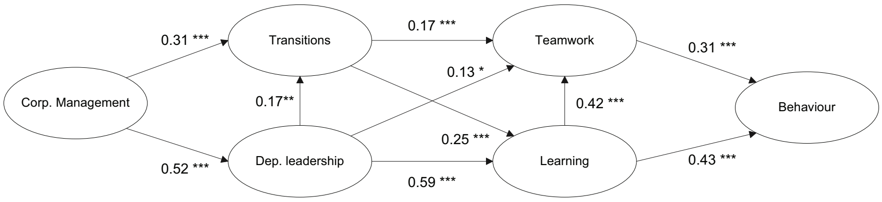

Fig. 3. Structural model tested on offshore workers in the petroleum sample with standardized path coefficients. *Note*: corp. management=organizational management support for safety; transitions= transitions and teamwork across units; dep. leadership=supervisor/manager expectations and actions promoting safety; teamwork=teamwork within units; learning=learning, feedback and improvement; behaviour=Stop working in dangerous situations. All paths are significant: * $p < .05$, ** $p < .01$, *** $p < .001$