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# The Brief Norwegian Safety Climate Inventory (Brief NORSCI) – Psychometric properties and relationships with shift work, sleep, and health

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ABSTRACT

The aim of this study was to establish the psychometric properties of the 11-item Brief Norwegian Safety Climate Inventory (Brief NORSCI) and to examine direct and indirect associations between shift work schedules, sleep problems, health complaints, and psychological safety climate. The study was based on a questionnaire survey in a randomly drawn cross-sectional sample of 8066 workers from the Norwegian offshore petroleum industry. The results showed that the Brief NORSCI has good psychometric properties. The three first order factors in the inventory could be combined in a composite second order safety climate factor with high construct and convergent validity. Workers on the different shift work schedules differed in levels of sleep problems and safety climate, but not with regard to health complaints. All non-day shift schedules reported significantly higher levels of sleep problems compared to day shift workers. Night shift workers had the most positive perceptions of safety. Shift work schedules had an indirect association with safety climate through sleep problems, but not through health complaints. These results provide tentative evidence for sleep problems as a potential explanatory factor in the shift work – psychological safety climate relationship. While this study has established the psychometric properties of the Brief NORSCI, as well as its relationships with shift work, health, and sleep, more research is needed in order to further determine the validity of the instrument.



## 1. Introduction

Safety climate reflects workers overall impression of available safety resources and whether the organization truly prioritize safety (Zohar, 2010). It is generally agreed that safety climate is the predominant antecedent to actual safety behavior and thereby to the potential occurrence of accidents and injuries (Barlow and Iverson, 2005). Valid and reliable assessments of an organization's safety climate are therefore important with regard to the prevention of occupational accidents through a continuous monitoring of safety factors. Yet, as most survey indicators of safety climate and safety perception are relatively extensive there is a risk that assessments of safety climate are excluded from organizational surveys and safety audits since they can be considered to be a burden to respondents. Hence, there is a need for short and concise indicators of safety climate with robust psychometric properties which can be incorporated in organizational surveys (Nielsen et al., 2013).

In addition to valid and reliable assessments of workplace safety, the prevention of occupational accidents and injuries are also dependent upon an understanding of the potential antecedents of safety. The arrangement of working hours is a crucial factor in the organization of contemporary working-life since many workers are engaged in 'non-standard' working hours, including shift and night work, part-time work, weekend work, compressed work week, varying working hours, split shifts, seasonal work, on-call work, and so on (Costa, 2003). A substantive body of research has established that shift work is associated with increased risk of accidents and reduced safety perceptions among employees (Folkard, 2008; Folkard et al., 2005; Folkard and Tucker, 2003). Furthermore, increasing evidence indicates that non-day shift-work schedules negatively influence worker physiology in the form of sleep and health problems (Akerstedt, 2003; Costa, 1996; Hystad et al., 2013; Peter et al., 1999; Wagstaff and Lie, 2011; Wright et al., 2013). Yet, few empirical studies have examined physiological factors as potential intervening

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mechanisms that determine how shift work is related to workplace safety.

In order to contribute to the literature on workplace safety, the aims of the present study were: (1) To determine the psychometric properties of The Brief Norwegian Safety Climate Inventory (Brief NORSCI; previously known as The Brief Norwegian Offshore Risk and Safety Climate Inventory) which is an 11-item inventory for assessing safety climate in safety critical organizations and occupations (Nielsen et al., 2013), and (2) to examine the relative impact of sleep problems and health complaints as potential intervening mechanisms in the association between shift work schedules and safety climate.

### 1.1. Measuring safety climate

The academic interest in the measurement of safety climate has resulted in a range of different assessment instruments. Typically, these measurements have been administered as self-report questionnaire surveys in various sectors, principally the energy industries, but also in manufacturing and construction (Flin et al., 2000). A common feature for most existing instruments is that they aim to measure a range of different safety factors. Consequently, most instruments include a relatively high number of items. According to Nielsen et al. (2013), large safety climate inventories can be problematic in both research and practical settings. First of all, a high number of items represents larger response burden, i.e., the effort required by the respondent to answer a questionnaire. Meta-analytic findings show that higher response burden in the form of questionnaire length is negatively associated with response rate (Rolstad et al., 2011). Hence, the use of comprehensive safety climate indicators may lead to fewer responses and thereby lower external and internal validity of findings. With regard to research, a high number of items are also problematic with regard to confirmatory factor approaches such as structural equation modeling in that larger sample sizes are needed to assure reliable analyzes of data (Nielsen et al., 2013). Finally, some of the existing inventories include a high number of subscales, something which makes it bothersome to conduct analyses, and report findings. For instance, the Nordic Safety Climate Questionnaire (NOSACQ-50) comprises 50 items and nine subscales (Kines et al., 2011). The well-established Safety Climate Questionnaire (Zohar and Luria, 2005), which includes 32 items, is another example.

Although it should be acknowledged that a major strength of long and comprehensive safety climate instruments is that they are able to assess a large spectrum of the safety climate phenomenon, the above limitations suggest that there is a need for shorter inventories. The 11-items Brief NORSCI inventory has recently been suggested as a short, but still theoretically meaningful and empirically anchored expression of safety climate (Nielsen et al., 2013). Yet, to this date, the psychometric properties of the instrument have only been examined in one single study (Nielsen et al., 2013), and there is a need for further examination of the instrument in order to establish it as a useful indicator of safety climate. First, while the findings from the study by Nielsen and colleagues showed that the Brief NORSCI is a valid and reliable indicator of the main dimensions of safety climate, the findings were based on two small and relatively homogeneous samples. The findings on psychometric properties should therefore be replicated in other, and preferably large and heterogeneous, samples. Second, in the study by Nielsen and colleagues, three different dimensions of safety climate were established through exploratory and confirmatory factor analyses. These were labeled "Individual intention and motivation", "Management's prioritization of safety" and "Safety routines". However, it was not determined whether these first order factors are dimensions of a second order factor representing an overall composite safety climate construct. Finally, in the study by Nielsen and colleagues, the authors did not provide any indications of construct validity of the inventory as the Brief NORSCI was not compared to the larger 35 item version of the instrument (Hope et al., 2010; Tharaldsen et al., 2008).

To replicate and extend the findings by Nielsen et al. (2013), we wanted to examine the first and second order factor structure of the Brief NORSCI, as well as its construct validity, in a large, heterogeneous sample of workers from the Norwegian offshore petroleum industry. If the first order factor structure described by Nielsen and colleagues can be explained by a theoretical meaningful and psychometrically sound higher order factor, this will further establish the Brief NORSCI as a valid indicator of safety climate.

### 1.2. Test of convergent validity: Relationships with shift work, sleep, health

In addition to having a theoretical meaningful factor structure with high internal stability, a valid indicator of safety climate should provide significant correlations with variables that are expected to be associated with safety climate. To test the convergent validity of the Brief NORSCI we will therefore investigate associations between the safety climate measure and correlates in the form of shift work, sleep, and health. In order to extend this examination of validity, we will also propose an overarching theoretical model for how shift work, sleep, health, and safety climates are related and provide a formal test of this model. Hence, through developing and testing a specific theoretical model, the current study will have additional theoretical and empirical contributions to the existing safety climate literature.

Shift work, defined as a way of organizing daily working hours in which different persons or teams work in succession to cover more than the usual eight hour day (Costa, 2003), has been proposed to be a significant antecedent of actual workplace safety as well as safety perceptions among employees (Berger and Hobbs, 2006; Folkard, 2008; Folkard and Tucker, 2003). Based on previous empirical findings and the Cognitive Activation Theory of Stress (Ursin and Eriksen, 2004), a potential explanation for how shift work influences safety climate is that irregular work hours have a negative impact on the psychological safety climate through sleep problems and health complaints as intervening variables (Fig. 1). In the upcoming sections, we will elaborate upon how sleep and health mediates the shift work-safety climate relationship.

It is well established that shift work is related to sleep (Parkes, 2012, 2015). According to Costa (1996), shift work, and in particular night work, compels the worker to invert the normal 'activity-rest' cycle forcing the worker to adjust his/her body function to the night activity period. Such 'adjustment' entails a progressive phase shift of the body's daily rhythmic functions, which increases with the number of successive night shifts, but seldom or never reaches

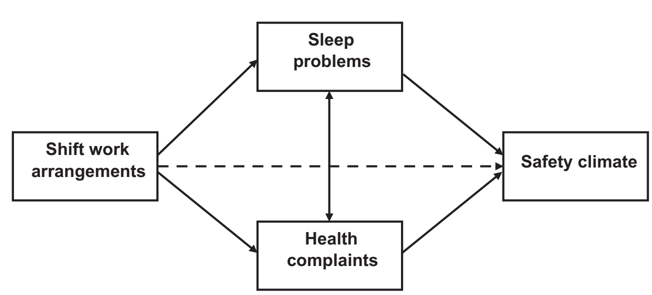


**Fig. 1.** Conceptual model for the relationships between shift work schedules, sleep problems, physical health complaints, and safety climate.

a complete inversion. This exposure to continuous strain in the attempt to adjust as quickly as possible to the new working hours, while at the same time being invariably frustrated by the continuous 'change-over', represents a perturbation of the rhythmic structure. This circadian drop in psycho-physical performance, in association with sleep deficit and stronger feeling of fatigue, decreases the work efficiency of the shift worker and increases the possibility of errors and accidents (Costa, 1996). It has also been suggested that shift work can have negative impact on general health and physical functioning (Costa, 1996; Kivimaki et al., 2006). While evidence is somewhat mixed (Berthelsen et al., 2015), there is also an extensive body of literature describing serious health related problems associated with participation in shift work (Parkes, 2012; Rosenberg and Doghramji, 2011). For instance, research findings show that gastrointestinal disorders are more common in shift workers than in day workers (Knutsson, 2003). Furthermore in a review of research findings on the association between shift work and cardiovascular disease it was concluded that shift workers had a 40% excess risk for cardiovascular disease compared to permanent day workers (Boggild and Knutsson, 1999).

Prolonged health problems and poor sleep quality has been associated with higher levels of fatigue and rumination (Kompier et al., 2012). Following the Cognitive Activation Theory of Stress (Eriksen and Ursin, 2004; Ursin and Eriksen, 2004), employees who engage in worry and rumination are more likely to interpret job stressors, in this case workplace safety, with negative expectancies (i.e., hopelessness and helplessness) such that they believe they either will fail or that there is nothing they can do about the stressor. This suggests that non-day shift work may lead to worry and rumination due to reduced sleep quality and increased health problems. If this worry and rumination are not coped with in a functional manner, workers will develop a more negative impression of available safety resources and the organization's prioritization of safety. Hence, the above evidence suggests that the association between shift work and psychological safety climate can be explained through sleep- and health problems as mediating variables. To add to the further understanding of the shift work – safety climate relationship, we will investigate the relative impact of sleep problems and health complaints as intervening mechanisms in the association between shift work schedules and psychological safety climate. Building on the above evidence, the following hypotheses will be tested:

**H1.** Shift work is related to safety climate in that workers on non-day shift schedules (permanent night shift, full shift, swing shift, or varying shift arrangements) have more negative impressions of safety climate compared to permanent day shift workers.

**H2.** Compared to day work schedule, non-day shift work is expected to have a more negative relationship with safety climate through health complaints and sleep problems.

## 2. Methods

In 1999/2000, the Norwegian Petroleum Directorate initiated the project "Trends in risk level – Norwegian shelf" to systematically evaluate safety issues on the Norwegian continental shelf. The main objective was to examine the overall health, safety and environment conditions in the petroleum industry. From 2004, the project was carried forward by the Petroleum Safety Authorities (PSA) in the form of an annual survey of safety indicators in the petroleum industry (Hope et al., 2010; Petroleum Safety Authority Norway, 2009).

The present study is based on data from the 2011 'Trends in risk level – Norwegian shelf" assessment. A questionnaire survey was carried out among all employees in the Norwegian offshore petroleum industry during the period from 17 October until 27 November 2011. Altogether 8066 forms were returned (response rate: 32%). The source population was pre-defined as anyone working in the Norwegian offshore sector in the period of the data collection. As all workers employed in companies operating at the Norwegian continental shelf at the time of the study was invited to participate in the survey, the sampling procedure can be consider as random. The sample comprises of 91% men, most predominantly within the age group from 31 to 50 years. In the sample 39% reported to have some sort of leadership responsibility and 61% had worked offshore for more than five years.

The Norwegian Petroleum Safety Authorities developed the questionnaire utilized in this study. Inclusion of the various variables and scales was based on a comprehensive review of the literature and included measures of sleep, risk and safety outcomes (Hope et al., 2010). Shift schedules were assessed by asking the respondents about their current shift arrangement. Response categories were permanent day shift, permanent night shift, full shift (14 nights/14 days every second tour), swing shift (7 days/7 nights every tour) or no specific shift arrangement (varying shift).

Safety climate was assessed with the 35 item version of the NORSCI (Hope et al., 2010; Tharaldsen et al., 2008). Respondents were asked to rate their agreement with statements concerning elements such as individual conditions for safe work execution, behavior characteristics relevant for safety, and situational aspects that influence safety behavior. The ratings followed a 5-point scale, ranging from 1 (fully agree) to 5 (fully disagree). To counteract response style bias, both positively and negatively keyed items are included in the inventory. The scores were reversed for the positively formulated items; hence on all the items a score of 1 would indicate evaluating the safety climate as poor, whereas a score of 5 would indicate evaluating it as good. As the aim of this study is to establish a brief version of the inventory, the questions from the 11 item Brief NORSCI (Nielsen et al., 2013) were retained for further analyses. In the original study by Nielsen et al. (2013) these 11 items were chosen on the basis of a series of exploratory and confirmatory factor analyses of the items in the 35 item version. Findings on psychometric properties, including internal consistency, are presented in the result section. As this is an individual level study, the Brief NORSCI was used to assess psychological safety climate, i.e., individual perceptions of safety-related policies, practices, and procedures pertaining to safety matters that affect personal well-being at work (Christian et al., 2009).

Sleep problems were measured with five items from the Trends in risk level – Norwegian shelf" as described by Hope et al. (2010). The respondents were asked to specify how often various statements regarding sleep and rest were appropriate for them, using a five-point scale, ranging from 1 = "very often or always" to 5 = "very rarely or never". Negatively formulated items were recoded so that for all items, a score of 1 indicated good sleep quality, while 5 indicated poor sleep quality. A confirmatory factor analysis of a single factor model with all items loading on one common factor indicated acceptable data fit for this indicator of sleep problems (CMIN = 239.59; df = 5; CFI = .97; TLI = .91; RMSEA = .076; 95% C.I. RMSEA = .068–.085). The scale had acceptable internal consistency (Cronbach's alpha = .73).

The respondents' subjective health complaints were measured with five items which asked the respondents about various issues related to physical health (headache, neck-, back-, and knee pain, and problems with hearing). The items used to assess health complaints are in line with items included in other indicators of subjective health complaints (Eriksen et al., 1999; Steingrimsdottir et al., 2004). Responses were given on a four point scale ranging from 1

"Not troubled" to 4 "Very troubled" (Cronbach's alpha = .66). This single factor indicator of health complaints with all items loading on one common factor showed good fit to data when tested with confirmatory factor analysis (CMIN = 209.523 df = 5; CFI = .97; TLI = .91; RMSEA = .064; 95% C.I. RMSEA = .057–.071).

### 2.1. Statistical analysis

Statistical analyses of direct and indirect associations were conducted using IBM SPSS Statistics 22.0 (IBM Corp. Released, 2013). All continuous variables were standardized prior to the analyses. Confirmatory factor analyses in SPSS AMOS 22.0 were used to establish the psychometric properties of the Brief NORSCI safety climate inventory. The goodness-of-fit of the structural regression models is usually evaluated using a chi-square value, with a non-significant *p*-value indicating a good fit. However, in large samples, even small and substantively unimportant differences between the estimated model and the "true" underlying model will result in rejection of the model that is tested (Bentler and Chou, 1987). Consequently, other indices of model fit were also considered. More specifically, we assessed the root mean square error of approximation (RMESA) with values of 0.06 or less, and a comparative fit index (CFI) and Tucker-Lewis Index (TLI) with values in the area of 0.90–0.95 as indicators of good fit (Hu and Bentler, 1999).

Differences in safety climate between shift arrangements were examined with One-way Analysis of Variance (ANOVA). Associations between safety climate, health, and sleep were determined with correlation analyses. The hypothesized indirect associations were tested by means of the MEDIATE script developed for SPSS (Hayes and Preacher, 2013). MEDIATE conducts mediation analysis (single and multiple mediators) with continuous, dichotomous, or multicategorical independent variables and offers features that accommodate multiple independent variables simultaneously and that simplify the coding of multicategorical independent variables. MEDIATE offers tests of relative direct and indirect relationships, including percentile bootstrap and Monte Carlo confidence intervals for indirect associations. See www.afhayes.com for further description and documentation. Bootstrap methods are implemented in the analyses of indirect associations. Bootstrapping is a statistical procedure that allows calculation of effect sizes and hypothesis tests for an estimate even when the underlying distribution is unknown. Bootstrapping is particularly useful in inferences about indirect effects because the normal theory approach (i.e. the Sobel test) is based on the premise that the sampling distribution of the indirect effect is normal, whereas both analytical and simulation work have demonstrated that the distribution can be quite irregular (Hayes, 2013).

## 3. Results

### 3.1. Psychometric properties of the Brief NORSCI inventory

To examine the psychometric properties of, and to confirm the expected higher order factor of safety climate in, the Brief NORSCI, we conducted a series of confirmatory factor analyses (CFA). In order to compare the three factor solution provided by Nielsen et al. (2013) with alternative models, we specified a one-factor model with all items loading on a single factor and different combinations of two-factor models where the items from each dimension in turn were specified to load on one of the alternative factors. The different structural models were compared using a chi-square test, and critical values of the chi-square distribution are taken as evidence of whether or not estimation of additional parameters is preferred (Jöreskog, 1993). Fit statistics and comparisons are presented in Table 1. The one-factor model had poor fit to the data (CMIN = 6,379.82; df = 44; CFI = .71; TLI = .56; RMSEA = .120; 95% CI RMSEA = .117–.122). Although all the three different variations of the two-factor model had somewhat better fit compared to the one-factor model, the employed fit-indicators showed that none of the two-factor models had good fit to the data. Hence, as the original three factor model had superior fit compared to the alternative one and two factor models, it was concluded that this solution provided the best representation of the data.

Following the employed criteria, this first order three factor solution had good fit to the data (CMIN = 1353.81; df = 41; CFI = .94; TLI = .90; RMSEA = .056; 95% CI RMSEA = .054–.059). With exception of the loading for the item "I stop working if I think it can be dangerous for me or other to continue" in the "Individual intention and motivation scale" which had a standardized factor loading of .39, all loadings exceeded 0.50 with no cross-loadings or error correlations. Overall model fit did not improve when removing the item with the low factor loading from the model (CMIN = 1253.98; df = 32; CFI = .94; TLI = .90; RMSEA = .061; 95% CI RMSEA = .058–.064). As removing the item did not change model fit, and since this item was considered as theoretical meaningful with regard to measuring the "Individual intention and motivation" factor, it was therefore retained in the final scale. The items, factors, and factor loadings for first order factors are displayed in Table 2.

All three first order factors provided strong loadings when specified on a second higher order factor representing the overall safety climate construct (CMIN = 1,353.81; df = 41; CFI = .94; TLI = .90; RMSEA = .056; 95% CI RMSEA = .054–.059). The "Safety routines" ($b$ = .86) and the "Management's prioritization of safety" ($b$ = .73) factors had the strongest loadings, whereas the "Individual

**Table 1**
Comparisons of different safety climate factor models.

| | $X^2$ | DF | CFI | TLI | RMSEA (90% C.I.) | Comparison | Δdf | Δ$X^2$ |
|---|---|---|---|---|---|---|---|---|
| 1. M1: One factor model[a] | 6379.82 | 44 | .71 | .56 | .120 (.117–.122) | | | |
| 2. M2: Two factor model[b] | 2784.61 | 43 | .87 | .81 | .080 (.077–.082) | | | |
| 3. M3: Two factor model[c] | 5376.59 | 43 | .76 | .62 | .111 (.109–.114) | | | |
| 4. M4: Two factor model[d] | 3970.97 | 43 | .82 | .72 | .095 (.093–.098) | | | |
| 5. M5: Three factor model[e] | 1353.81 | 41 | .94 | .90 | .056 (054–.059) | 5 vs. 1 | 3 | 5026.01*** |
| | | | | | | 5 vs. 2 | 2 | 1430.80*** |
| | | | | | | 5 vs. 3 | 2 | 4022.78*** |
| | | | | | | 5 vs. 4 | 2 | 2617.16*** |

*** $p < .001$.
[a] All items loading on a single factor.
[b] Items in "Management's prioritisation of production vs. Safety" and "Safety routines" loading on one factor.
[c] Items in "Individual intention and motivation" and "Management's prioritisation of production vs. Safety" loading on one factor.
[d] Items in "Individual intention and motivation" and "Safety routines" loading on one factor.
[e] Items loading on three separate factors.

**Table 2**
Factor structure for the 11 item Brief NORSCI inventory.

| Subscale | Item | 1 | 2 | 3 |
|---|---|---|---|---|
| 1. Individual intention and motivation | I report dangerous situations when I see them | .74 | | |
| | Safety has top priority when I do my job | .68 | | |
| | I ask my colleagues to stop work when I think the task in question is being carried out in a risky manner | .61 | | |
| | I stop working if I think it can be dangerous for me or other to continue | .39 | | |
| 2. Management's prioritisation of safety | In practice concern for production precedes the concern for health, environment and safety | | .68 | |
| | Reports on accidents or dangerous situations are often "smartened up" | | .68 | |
| | There are often parallel work operations proceeding that leads to dangerous situations | | .57 | |
| | Lack of maintenance has resulted in reduced safety | | .53 | |
| 3. Safety routines | I have the necessary competence to perform my job in a safe manner | | | .57 |
| | I have easy access to personal protective equipment | | | .59 |
| | The safety deputies' suggestions are taken seriously by the management | | | .68 |

intention and motivation" factor had the lowest loading ($b = .59$). Yet, the strength of the factor loadings suggests that all first order factors contribute to the variance in the second order factor.

Taking the number of items in the scales into account, the Brief NORSCI subscales had acceptable internal consistency as measured by Cronbach's alpha (Pallant, 2005; Streiner and Norman, 1989): "Individual intention and motivation" (4 items; alpha = 0.64), "Management prioritisation of production vs. Safety" (4 items; alpha = 0.72), and Safety routines (3 items; alpha = 0.67). Cronbach's alpha for the 11 item second order factor was .77.

In order to test the construct validity of the inventory, the Brief NORSCI was correlated with the 35 item Full version of the instrument as described by (Hope et al., 2010). Correlating the 11 item Brief NORSCI with the Full version yielded a correlation of .92 ($p < .001$). This indicates that the Brief NORSCI is highly related to the larger inventory and thereby has high construct validity.

### 3.2. Relationships between shift work, health, sleep, and safety climate

The means, standard deviations, and intercorrelations for all study variables are presented in Table 3. At an average, respondents rated the safety climate as very positive ($M = 4.20$; SD = .53). Levels of sleep problems ($M = 2.07$; SD = .73) and health complaints ($M = 1.58$; SD = .47) were relatively low. The overall safety climate indicator had significant negative associations with sleep problems ($r = -.38$; $p < .001$) and health complaints (−.28; $p < .001$). Similar associations with health complaints and sleep problems were found for the three subscales. Health complaints were positively correlated with sleep problems ($r = .40$; $p < .001$). As displayed in Table 3, correlations with sleep and health problems were of similar magnitude for the Brief and the Full NORSCI scales, something which suggest that the Brief NORSCI has strong convergent validity.

**Table 4**
Differences in perception of safety climate between shift work schedules.

| Shift work schedules | Safety climate | |
|---|---|---|
| | $M$ | SD |
| (a) Day shift | $4.24_{b-e}$ | .53 |
| (b) Night shift | $4.38_{a}$ | .49 |
| (c) Full shift | $4.07_{a,d,e}$ | .54 |
| (d) Swing shift | $4.21_{a,c,e}$ | .53 |
| (e) Varying shift | $4.13_{a,c,d}$ | .50 |
| Differences | $F = 26.88$; df = 4/7731; $p < 0.001$ | |

*Note:* Subscript after mean values displays group differences. E.g., $_{b-e}$ shows the score for category (a) Day shift is significantly different from categories b, c, d, and e.

A one-way ANOVA (see Table 4) showed significant differences between the shift work categories with regard to psychological safety climate ($F = 26.88$; df = 4/7731; $p < 0.001$). Respondents on night shift reported significantly more positive safety climate compared to the other shift work categories. Day shift workers reported more positive safety climate compared to full shift and varying shift workers, while they had more negative perceptions of safety climate compared to night shift workers. No differences in safety climate were found between day shift workers and swing shift workers. Respondents on full shift arrangements reported significantly more negative safety climate compared to day shift, night shift, and swing shift workers, while their safety climate ratings was more or less equal to those on varying shift arrangements. Swing shift workers reported significantly more positive safety climate compared to varying and full shift workers, but more negative safety climate than night shift workers. Summarized, the findings provided partial support for Hypothesis 1 in that workers on full, swing and varying shifts, but not on night shift, reported more negative perceptions of safety climate compared to day workers.

Potential indirect associations between shift work schedules and safety climate through sleep problems and health complaints were tested by following the procedures for mediation analysis with multi-categorical independent variable as suggested by Hayes and Preacher (2013). Regular day shift arrangement was used as reference category in analyses. Bootstrapping was set to 5000 resamples. The main findings are summarized in Table 5. In the direct association model, shift schedules, sleep problems and

**Table 3**
Means, standard deviations, and intercorrelations for all study variables. Cronbach's alpha in bold along the diagonal.

| | Variables | No of items | Response scale | Correlations | | | | | | | Descriptives | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 2a | 2b | 2c | 3 | 4 | $M$ | SD |
| 1 | Full NORSCI | 35 | 1–5 | **.92** | | | | | | | 4.15 | .50 |
| 2 | Brief NORSCI total scale | 11 | 1–5 | .92 | **.77** | | | | | | 4.20 | .53 |
| 2a | Individual intention and motivation | 4 | 1–5 | .62 | .63 | **.64** | | | | | 4.69 | .47 |
| 2b | Management's prioritisation of safety | 4 | 1–5 | .79 | .88 | .30 | **.72** | | | | 3.49 | .94 |
| 2c | Safety routines | 3 | 1–5 | .64 | .70 | .35 | .41 | **.67** | | | 4.49 | .62 |
| 3 | Sleep problems | 5 | 1–5 | −.43 | −.38 | −.22 | −.33 | −.28 | **.73** | | 2.07 | .73 |
| 4 | Health complaints | 5 | 1–4 | −.32 | −.28 | −.12 | −.28 | −.19 | .40 | **.66** | 1.58 | .47 |

*Note:* All correlations significant at the $p < .001$ level (two tailed).

**Table 5**
Results for sleep problems and physical health complaints as mediators of the relationship between shift work and safety climate.

| Predictor | B | SE | t |
|---|---|---|---|
| *Direct associations model (DV = safety climate)* | | | |
| Day shift (Ref. cat.) | – | – | – |
| Night shift | .37 | .07 | 5.33** |
| Full shift | −.15 | .04 | −3.61** |
| Swing shift | .07 | .03 | 2.83* |
| Varying shift | −.11 | .03 | −3.50** |
| Sleep problems | −.31 | .01 | −26.73** |
| Physical health complaints | −.16 | .01 | 13.54** |
| Constant | .00 | .02 | .22 |
| Omnibus test for direct associations: $R^2$ = .01; $F$ = 18.92; DF = 4/7567; $p$ < .001 | | | |

| Predictor | B | Bootstrapped SE | 95% BCa CI |
|---|---|---|---|
| *Mediator model I: Sleep problems* | | | |
| Day shift (Ref. cat.) | – | – | – |
| Night shift | −.14 | .03 | −.19 to −.09 |
| Full shift | −.18 | .02 | −.21 to −.15 |
| Swing shift | −.13 | .01 | −.15 to −.11 |
| Varying shift | −.10 | .01 | −.12 to −.08 |
| *Omnibus effect* | *−.01* | *.00* | *−.02 to −.01* |
| *Mediator model II: Physical health complaints* | | | |
| Day shift (Ref. cat.) | – | – | – |
| Night shift | .02 | .01 | −.00 to .04 |
| Full shift | −.01 | .00 | −.02 to .01 |
| Swing shift | .00 | .00 | −.01 to .01 |
| Varying shift | −.01 | .00 | −.01 to .01 |
| *Omnibus effect* | *−.00* | *.00* | *−.001 to .001* |

*Note:* BCa CI: Bias corrected and accelerated Confidence Interval. An omnibus test of the direct effect of the independent variable is conducted by ascertaining whether the addition of the independent variable to a model of containing only proposed mediators and covariates improves the fit of the model, as indexed by a change in the squared multiple correlation that results when the independent variable is added (see http://www.afhayes.com/public/mediate.pdf).
** $p$ < 0.001.
* $p$ < 0.01.

health complaints were all directly associated with safety climate. Sleep problems ($B = -31$; $p < 0.001$) and working night shift ($B = .37$; $p < 0.001$) emerged as the strongest correlates of safety climate.

The findings on indirect associations showed that sleep problems (Omnibus = −.01; 95% BCa CI = −.02 to −.01), but not health complaints (Omnibus = .000; 95% BCa CI = −.001 to .001), mediated the relationship between shift work arrangements and safety climate. Relative to the control condition, non-day shift work schedules had a significantly stronger negative indirect association with safety climate through sleep problems. As indicated by the overlapping confidence intervals for the shift work categories shown in Table 5, there were no differences in the strength of the indirect associations between the different non-day schedules. Altogether, shift work schedules, sleep problems, and health complaints explained 17.1% of the variance in safety climate. The model was significant ($F = 259.61$; df = 6/7567, $p < 0.001$). Taken together, our second hypothesis about indirect associations was supported for sleep problems, but was rejected for health problems.

## 4. Discussion

The aims of this study were to determine the psychometric properties of the Brief NORSCI and to investigate direct and indirect relationships between shift work arrangements and safety climate through sleep problems and health complaints. Replicating a previous validation study of the Brief NORSCI (Nielsen et al., 2013) in a new and considerably larger sample comprising employees from the offshore petroleum industry, the findings indicated sound psychometric properties of the Brief NORSCI. Extending previous research, it was shown that the three previously established first order factors can be combined in a composite second order safety climate factor with high construct and convergent validity. In line with our expectations, safety climate were negatively correlated with sleep problems and health complaints. Finally, the findings showed that shift work schedules had an indirect association with safety climate through sleep problems, but not health complaints. This indicates that the direct associations between non-day shift work schedules and safety climate are significantly reduced when sleep problems are adjusted for. Hence, non-day shift work is associated with more sleep problems which again are related to a more negative rating of safety climate.

In a review of safety climate measurement instruments, Flin et al. (2000) found five emergent themes which were included in most inventories: (1) Management, (2) Safety system, (3) Risk, (4) Work pressure, and (5) Competence. In the following we will describe how the Brief NORSCI adheres to these five themes. "Management" is considered to represent a prime theme in most instruments. This aspect of safety climate is related to perceptions of management attitudes and behaviors in relation to safety, production, discipline, and planning. In the Brief NORSCI scale, "Management" is measured with the scale "Management's prioritization of safety". This subscale comprises four items which reflect external framework conditions affecting safety or safety prioritization and thereby how management prioritizes the relative significance of safety versus production and maintenance. Some of these items are also indicators of "Work pressure" and refers to the balance maintained between pressure for production and safety.

The Brief NORSCI subscale of "Safety routines" includes items focusing on individual safety precautions and safety skills and assesses safety competence and knowledge about safety routines among workers. With regard to the safety climate categories established by Flin et al. (2000), the safety routines subscale corresponds to "Safety system" and "Competence". According to the review by Flin and colleagues, "Safety system" encompassed many different aspects of the organization's safety management system, including safety officials, safety committees, permit to work systems, safety policies, and safety equipment. "Competence" reflects the workforce's perception of the general level of workers' qualifications, skills and knowledge is the essence of this competence factor, with associated aspects relating to selection, training, competence standards and their assessment (Flin et al., 2000).

According to Flin et al. (2000) the risk theme appears in a number of conceptual guises in measures of safety climate, namely, self-reported risk taking, perceptions of risk/hazards on the worksite and attitudes toward risk and safety. The items in the Brief NORSCI subscale labeled "Individual intention and motivation" deals with workers safety behavior by investigating the what "I do" with regard to risks and safety (Nielsen et al., 2013). Hence, by examining workers intentions, behavior, and motivation in hazardous situations this part of the scale overlaps with the "Risk"-dimension identified in the review by Flin et al. (2000). Previous studies of risk perception in offshore workers have shown that workers have fairly accurate perceptions of the risks they face (Flin et al., 1996; Rundmo, 1992). These findings suggest that the self-reported assessment of risk and safety behavior included in the Brief NORSCI provides a valid assessment of risk levels.

In the analyses of convergent validity, both the composite measure of safety climate and the three subscales correlated in expected directions with sleep problems and health complaints. Correlations with sleep and health problems were of similar magnitude for the Brief and the Full NORSCI scales. In line with previous research, differences in safety climate were found between different shift work categories. However, going against expectations, it was found that workers at night schedules perceived the safety climate as more positive compared to other schedules. There may be several explanations for this finding. In some cases it is possible that the overall levels of risks are reduced due to lowered production at night. Another explanation is that workers on night shift schedules comprise an especially resilient group of employees. That is, it may be that persons who work night shift have specific personality dispositions that influence their safety perceptions. This latter explanation is supported by a systematic review which showed that young age, male gender, low scores on morningness, high scores on flexibility and low scores on languidity, low scores on neuroticism, high scores on extraversion and internal locus of control and some genetic dispositions are related to higher shift work tolerance (Saksvik et al., 2011).

Extending previous research, the results of this study indicate that sleep problems, but not health complaints, is an intervening variable which may explain how shift work schedules are associated with safety climate. Although it should be emphasized that the cross-sectional design limits conclusions about causal relationships, the findings show that all non-day shift arrangements reported significantly stronger negative indirect associations through sleep problems compared to day shift workers. An interpretation of this finding is that workers on non-day shift schedules who experience sleep problems seem to have a more negative impression of safety compared to their day shift colleagues. This suggests that interventions to improve safety in shift work occupations ought to take sleep and opportunities for restitution and rest breaks into consideration (Folkard and Tucker, 2003). Yet, as shift work also had a prominent direct association with safety perception after adjusting for the indirect associations, future research should also aim at determining other potential intervening mechanisms of the shift work – safety climate relationship.

### 4.1. Methodological considerations

In the interpretation of the findings some potential strengths and limitations should be observed. In terms of strengths, the present study is based on a fairly large and randomly selected sample of Norwegian offshore workers from all companies operating in the Norwegian petroleum industry. Thus, it should be possible to generalize our findings to similar occupational groups. As for internal validity, the study variables were measured with psychometrically sound and valid instruments. It should be noted that the multi-categorical approach to the analyses of indirect associations extends previous research where shift work schedules have been collapsed into only two categories. Due to challenges with analyzing indirect pathways from multicategorical predictor variables (Feinberg, 2012; Iacobucci, 2012), previous research on the indirect effects of shift work has usually collapsed multiple shift work schedules into fewer categories (e.g., Peter et al., 1999), thus reducing variability in, and the understanding of the effects of, shift work. In the current study, we applied a newly developed approach for the analysis of indirect effects where it was possible to maintain multiple categories in the predictor (Hayes and Preacher, 2013). Hence, an important secondary contribution of this study is that it demonstrated the usefulness of this method to the statistical analysis of indirect pathways from shift work.

With regard to limitations, all data were collected using self-report methods. Hence, there is the possibility of common method variance and response set tendencies. In addition, the cross-sectional nature of the sample does not allow for conclusion about causal relationships between variables. Although this study is based on the theoretical assumption that sleep problems and health complaints mediate the relationship between shift work schedules and safety climate, other relationships between these variables are also possible. To indicate causality, longitudinal or experimental studies are needed in future research.

While the current study has established the factor structure of the Brief NORSCI and provided evidence for the construct and convergent validity of the inventory through its associations with other constructs, we have not examined any other forms of validity or shown the test–retest reliability of the inventory. In order to further develop and strengthen the instrument, future research should aim at determining the criterion and discriminant validity of the inventory. By employing the instrument in other occupational settings and with time-lagged data, it will also be possible to assess the external validity and test–retest reliability of the Brief NORSCI. Finally, as the Brief NORSCI has only been employed to examine psychological safety climate in individual level studies, up-coming research should also collect group-level data in order to test the Brief NORSCI as a group climate measure (Christian et al., 2009).

## 5. Conclusions

The current study supports the Brief NORSCI as a psychometrically sound short-form instrument for the assessment of safety climate. Comprising 11 short and easy-to-read items, thus easing the mental load and time demands on respondents, the technical application of the Brief NORSCI is simple. As survey length is generally an issue in most organizational studies with regard to response burden and response rate, the Brief NORSCI is a comprehensible, yet short and valid instrument. The content of the items in the Brief NORSCI reflects specific areas of safety and covers the most frequently investigated dimensions of safety climate (Dedobbeleer and Beland, 1998; Flin et al., 2000). Hence, the specificity of these items allows organizations to determine why employees' perceptions of safety climate may be poor and can thereby provide a means for improving safety climate (Nielsen et al., 2013).

As existing safety climate inventories are relatively extensive and time consuming, they increase the risk for non-response as well biased responses. With a short inventory such as the Brief NORSCI it is reasonable to assume that a higher number of respondents will read each individual item and respond to these items in a precise manner. Hence, with regard to practice, it is likely the Brief NORSCI will provide a more accurate snapshot of the current state of safety than more comprehensive inventories. While the psychometric tests of the Brief NORSCI have been done in petro-maritime occupations, the wording of the included items is neutral and does not refer to any specific occupational settings. This suggests that the inventory also can be used to assess safety climate in other occupations were safety is a critical factor.

The results of this study indicate that workers on different shift work schedules differ in levels of sleep problems and safety perceptions, but not with regard to health complaints. Furthermore, the findings provide tentative evidence for sleep problems, but not health complaints, as a potential mediating factor in the association between shift work schedules and safety climate. Taken together, these findings suggest that safety critical organizations may benefit from developing routines for promoting sleep and restitution among shift workers in order to improve safety climate.

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