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Safety climate and health complaints in the Norwegian aquaculture industry

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ABSTRACT

Few studies have explored the potential connection between safety climate and health issues. However, some recent research findings indicate that a poor safety climate can be considered a stressor that may be associated with physical symptoms and musculoskeletal complaints. This link is further explored in the present study on the basis of a questionnaire study of 446 sharp-end workers in the Norwegian aquaculture industry. The analysis revealed that self-reported health complaints (musculoskeletal pain, headaches and fatigue) are negatively related to safety climate, i.e. the more positive the safety climate, the fewer the health complaints. The study finds that the following two safety climate factors are particularly important: work pressure and safety involvement. This means that self-reported health complaints are higher among workers who experience (a) a prioritisation of production and efficiency at the expense of safety, and (b) a lack of involvement in safety decisions. Regarding relevance to the industry, these relationships indicate the existence of a supplementary managerial pathway for the prevention of occupational health issues.

1. Introduction

Since Zohar (1980) original study that introduced and defined the safety climate concept, considerable work in this field has focused on the relationship between safety climate and the safety performance of high-risk organisations. A substantial number of studies have found that safety climate, defined as the set of perceptions that employees share regarding the priority of safety in their organisation, can influence employees' attitudes towards safety, the way co-workers interact with each other on safety issues and how safely employees are working (Clarke, 2006; Neal and Griffin, 2004; Zohar, 1980). For example, a positive safety climate has been identified as a significant contributor to promoting workers' propensity to comply with safety procedures (Lu and Yang, 2011), encouraging workers' participation in safety issues (e.g. Smith et al., 2016), and advancing mindful safety practices (Dahl and Kongsvik, 2018). This demonstrates that employees who perceive that safety is being prioritised within their workplace display positive safety behaviours.

Moreover, other studies have found a positive relationship between safety climate and material safety outcomes. For example, Kongsvik et al. (2011) study within the oil and gas industry noted that safety climate can be used as a leading indicator of hydrocarbon leaks, Lu and Tsai (2008) study of seafarers found that negative safety climates affect crew fatality incidences, and Neal and Griffin (2006) study of hospital employees recognised that an improved safety climate is associated with a subsequent reduction in workplace accidents.

In spite of the acknowledged relationship between safety climate on the one hand and safety attitudes, safety behaviour and material safety outcomes on the other, few studies have focused on the potential relationship between safety climate and health issues. However, according to Golubovich et al. (2014), negative safety climates can act as a psychosocial stressor that may elicit frustration and subsequently increase the rate of work-related musculoskeletal disorders. This link between safety climate and health complaints is supported by some other recent studies. For example, Hystad et al.'s study of seafarers in the offshore oil and gas industry (2013) found that a negative safety climate is related to mental fatigue, physical fatigue and lack of energy, while Arcury et al. (2012) study among farmworkers found that negative safety climates are associated with elevated musculoskeletal discomfort.

Based on a survey of sharp-end workers in the Norwegian

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aquaculture industry (Thorvaldsen et al., 2017), the objective of the present study was to further explore the relationship between safety climate and health complaints, by analysing the ways in which perceived safety climate influences self-reported health complaints. Four types of health complaints, which are typical for studies that focus on psychosocial stressors (e.g. Eatough et al., 2012; Wahlstedtet al., 2010) were analysed. These were: (1) arm, shoulder and neck complaints; (2) hand and wrist complaints; (3) headaches; and (4) fatigue. Compared to traditional safety climate studies, in which the prime focus is on the relationship between safety climate and safety performance, research on this topic may yield insights into the broader impact of safety climate on the working environment.

1.1. The Norwegian aquaculture industry

The aquaculture industry has become one of the most important industries in Norway and has grown considerably since the start in the 1970s, both in terms of employment and production (Holmen et al., 2017). Production and export of salmon is highly profitable, and there are ambitions to increase the production further.

Salmon is the main species produced and represent 93% of the farmed biomass in Norway (Directorate of Fisheries, 2017a). Sea-based salmon farms consist of several net cages, which the employees access by boat. Each fish farm site will typically employ one or two teams of three to four people who work closely together. Shift work is common at many fish farms. Each shift is managed by an operational manager who is responsible for operations, personnel and production. Fish farmers are responsible for the fish, ensuring that they are healthy and growing. Fish farmers use work vessels with cranes to perform some of their work tasks, whereas more specific tasks such as mooring are performed by service vessel crews that may be either independent or part of the company. The development of new technological concepts for fish farming and the shifting of production to more exposed areas as regards climate, wind and currents entail new challenges for workers in this industry (Bjelland et al., 2016).

In spite of new technological innovations, the work continues to involve several manual tasks that may prove straining and repetitive for employees (Holmen and Thorvaldsen, 2018). A significant proportion of fish farmers reported experiencing work-related musculoskeletal problems, including pain in the neck, shoulders (27%), back (19%) and hands and wrists (12%).[1] According to employees, strain and acute injuries are the main causes of their work-related sickness absences and health concerns (Thorvaldsen et al., 2017). Accident rates in aquaculture are high relative to most other Norwegian industries, and common injury modes for employees at fish farms include falls, blow by object, entanglements/crush and cuts (Holen et al., 2018).

In recent years, emphasis on occupational health and safety, safety management and measures such as safety training for personnel has increased. Employees in the industry generally perceive the safety climate positively, but challenges pertaining to work pressure, maintenance and employee participation have also been identified (Kongsvik et al., 2018).

2. Theory

2.1. The concept of safety climate

In recent decades, the organisational context for work has become increasingly recognised for having a strong significance for work safety (Hale and Hovden, 1998; Reason, 1997; Weick et al., 1999). The organisational wave in safety science includes a large amount of research on safety culture and climate from the 1990s until the present day (Antonsen, 2009; Casey et al., 2017). Safety climate involves the shared perceptions in a work community regarding safety policies, procedures and practices, and regarding how safety is managed and valued (Casey et al., 2017; Griffin and Neal, 2000; Zohar, 2003). Thematically, the construct embraces issues such as management commitment and prioritisation, safety systems (i.e. procedures and reporting), competence and training, work pressure and employee participation (Beus et al., 2010; Flin et al., 2000). Safety climate can be seen an organisational antecedent that influence proximal factors such as safety knowledge, safety skills and safety motivation, which in turn influence work behaviour.

Many studies exploring the interrelationships between safety climate and safety outcomes exist. A rather consistent finding over time and across different industries has been that a positive safety climate is associated with safety-compliant behaviour and good safety participation (Christian et al., 2009; Clarke, 2006; Jimmieson et al., 2016; Petitta et al., 2017). A positive safety climate is also related to mindful safety practices, i.e. work practices that can prevent or interrupt unwanted event sequences (Dahl and Kongsvik, 2018; Skjerve, 2008). Moreover, a positive safety climate is associated with fewer accidents and injuries at work (Kongsvik et al., 2011; Leitão and Greiner, 2016; Olsen et al., 2015; Vinnem et al., 2010), potentially mediated by behaviour (Clarke, 2006).

Even if the causal relationships need to be explored further (Leitão and Greiner, 2016), studies indicate a causal pattern involving safety climate, proximal factors (knowledge, skills and motivation), safety performance (different types of behaviour) and safety results (accidents and injuries).

2.2. Safety climate and health complaints

Musculoskeletal disorders (MSDs) are painful disorders involving the muscles, tendons, joints and nerves, and commonly affecting the neck, upper limbs and back (Van Eerd et al., 2016). In 2012, the prevalence of MSDs in Norway was estimated at 18% among men and 27% among women (Kinge et al., 2015). Occupational MSDs have different origins, with Hernandez and Peterson (2013) defining three broad categories: (1) individual risk factors; (2) biomechanical risk factors; and (3) psychosocial risk factors. A range of different individual risk factors have been proposed. The prevalence of MSD increases with age and women are more exposed than men (Holmström and Engholm, 2003; Kinge et al., 2015). In addition, smoking and greater body mass index (BMI) have been identified as risk factors (da Costa and Vieira, 2010). Biomechanical risk factors include repetitive movements of body parts or static/improper work positions and heavy lifting, which increase physical load and mechanical strain (da Costa and Vieira, 2010). Psychosocial factors in the work environment (e.g. work load, time pressure, autonomy and social support) are increasingly acknowledged as risk factors for MSD (Golubovich et al., 2014). Such factors have been studied in light of the Demand-Control-Support model (Johnson and Hall, 1988), in which the combination of the stressors high job demands, low control, and low co-worker social support is associated with negative health outcomes. Pertaining to neck and upper limb problems, Bongers et al. (2006) conclude on the basis of a review study that all three dimensions and combinations represent risk factors for neck and upper limp symptoms, albeit modest in effect.

Similarly, the job demands-resources model (JD-R) has been found useful in explaining work-related MSD. The basic assumption of the JD-R model is that job strain is the result of a disturbance of the balance between the demands workers are exposed to on the one side, and the resources they have available on the other (Bakker and Demerouti, 2007). Job demands analysed are typically quantitative demands, emotional demands and work pace, whereas job resources analysed typically include decision authority, skill discretion and supervisor support (Sommovigo et al., 2019). Several studies have found that disturbance of the balance between job demands and resources leads to

[1] The respondents considered the potential problems on a 5-point Likert scale. The percentages represent the proportion of respondents who reported the problems to a large or very large extent.

job strain which, in turn, leads to MSD (e.g. Airila et al., 2014; Sprigg et al., 2007). For example, a study by Glaser et al. (2015) found that high job demands, low supervisor feedback, and low autonomy were associated with emotional strain, which in turn predicted musculoskeletal pain.

Safety climate can clearly be considered a psychosocial factor. Similar to measures of JD-R, measures of safety climate typically consist of some negatively loaded dimensions, e.g. work pressure, and some positively loaded dimensions, e.g. supervisor support for safety (Flin et al., 2000). However, measures of safety climate are safety specific, not generally work related. In ergonomics, safety climate research remains scarce (with some notable exceptions, e.g. Huang et al., 2016), although contextual and organisational factors are considered as having significant relevance in a systems perspective and for workplace health issues such as MSD (Bentley and Tappin, 2010). Nevertheless, some recent studies have explored safety climate empirically as a risk factor for MSD. For instance, in a study of horse farm workers, Swanberg et al. (2017) found that musculoskeletal discomfort in the neck, back and upper extremities was associated with poor safety climate. Furthermore, in a qualitative study in the meat processing industry (Tappin et al., 2008), safety culture was identified as an influential factor regarding the risk of MSD. Moreover, Arcury et al. (2012) found that negative safety climates were associated with elevated musculoskeletal discomfort among farmworkers. In another interesting study, Golubovich et al. (2014) proposed and empirically tested a model in which a poor psychological safety climate was expected to function as a stressor, for example when management was perceived as not emphasising safety, safety training and communication was poor, and there was little availability of safety policies and procedures. Quite similar to Glaser et al. (2015) JD-R based study, Golubovich et al. (2014) safety climate study hypothesised that the efforts invested in coping with such organisational constraints would stimulate frustration as a strain response. Frustration might increase vulnerability to work-related MSD, such as by increasing muscular tensions, reducing immune system responses, and increasing pain sensitivity. In line with a transactional approach, stress was regarded as a dynamic process in which personal and environmental factors interact. The personal variable 'psychological hardiness' was analysed as a buffer to frustration. High rates of hardiness involved interpreting stressful situations as opportunities, being committed to solving challenging situations, and feeling in control of challenging situations.

In the analysis of survey data involving 464 full-time working respondents, the model was supported. Good safety climate was associated with lower rates of frustration and fewer work-related MSD complaints. Psychological hardiness moderated the climate-frustration relationship, although not in the expected direction: hardiness was found to strengthen the climate-frustration relationship, rather than weakening it (Golubovich et al., 2014).

When a poor safety climate represents a stressor in a work context, other health symptoms besides MSD complaints may also be expected to occur. Headache has been associated with stress in numerous studies (Holm et al., 1986; Houle and Nash, 2008; Nash and Thebarge, 2006; Nixon et al., 2011). Stress can contribute to the onset of a headache disorder, exacerbate the progression from episodic to a chronic condition, and exacerbate individual episodes (Nash and Thebarge, 2006). Fatigue can be defined as 'an overwhelming sense of tiredness, lack of energy and a feeling of exhaustion, associated with impaired physical and/or cognitive functioning' (Shen et al., 2006:70). Fatigue can be seen as a result of exertion, such as related to organisational factors (Phillips, 2015). Stress is established as being a precursor to fatigue (Åkerstedt et al., 2002). Hystad et al. (2013) found an association between safety climate and fatigue among seafarers.

Consistent with the literature reviewed above, and in line with previous JD-R studies (e.g. Airila et al., 2014; Glaser et al., 2015; Sprigg et al., 2007), and Golubovich et al. (2014) safety climate study, the present study assumed a relationship between safety climate and health complaints. More specifically, the following hypotheses were proposed:

Hypothesis 1. Arm, shoulder and neck complaints will be negatively related to safety climate (i.e. the more positive the safety climate, the fewer the arm, shoulder and neck complaints).

Hypothesis 2. Hand and wrist complaints will be negatively related to safety climate (i.e. the more positive the safety climate, the fewer the hand and wrist complaints).

Hypothesis 3. Headaches will be negatively related to safety climate (i.e. the more positive the safety climate, the fewer the headaches).

Hypothesis 4. Fatigue will be negatively related to safety climate (i.e. the more positive the safety climate, the lower the rate of tiredness).

The relationships to be explored are illustrated in Fig. 1. Four safety climate dimensions were included; work pressure, safety priority, safety involvement and safety competence. A positive safety climate was defined as being low on work pressure, and high on safety priority, safety involvement and safety competence.

3. Method

3.1. Data collection and sample

The present study is based on a survey conducted as part of the project *Safer Operations and Workplaces in Fish Farming* (Thorvaldsen et al., 2017). A questionnaire was developed on the basis of previous studies of safety climate within other high-risk industries (e.g. Fenstad et al., 2016), public health surveys (e.g. Krokstad and Knudtsen, 2011), and a HSE survey applied in the fishing industry (Sonvisen et al., 2017). The study received approval from The Data Protection Official for Research in Norway, and was completed in compliance with research ethical requirements from the Norwegian Centre for Research Data (NSD, 2018).

The aim of the questionnaire was to measure the health, safety and environmental conditions for production site workers within the Norwegian aquaculture industry, and to provide knowledge of risk factors, health complaints and organisational and technological challenges. A part of the questionnaire was designed as a safety climate survey. Several questions about health complaints, exposures and job satisfaction were also included (Thorvaldsen et al., 2017).

All respondents were interviewed by telephone. A polling company conducted the survey, and a total of 447 out of a sample of 735 preselected employees agreed to participate, giving a response rate of 60.8%. The respondents' demographics are presented in Table 1. The gender distribution shows that 95.5% of the respondents were men. This is fairly representative of the Norwegian aquaculture industry as a whole, in which roughly 82% were men in 2017 (Directorate of Fisheries, 2017). The slight overrepresentation of men might be caused by the fact that employees working within administrative, land-based positions and with fish processing were not included in the survey. Among the respondents, fish farmers/technicians constituted the largest group (57.7%), followed by operational managers (24.6%), service vessel workers (13.4%) and others (4.3%). The age distribution shows that roughly half of the respondents were above 40 years (48.7%). The majority of the respondents had 10 years of experience or less within the aquaculture industry (55.3%).

3.2. Measures and statistical procedures

3.2.1. Variables and factor analysis

The questionnaire employed consisted of 90 questions pertaining to demographics, health complaints, perceived risk, working environment, safety behaviour and safety evaluations. The 25 items related to safety climate were largely based on Flin et al. (2000) review of safety climate questionnaires and Fenstad et al. (2016) study of safety climate within the passenger ferry industry. Sixteen of these were selected to measure safety climate and four were selected to measure health complaints (see

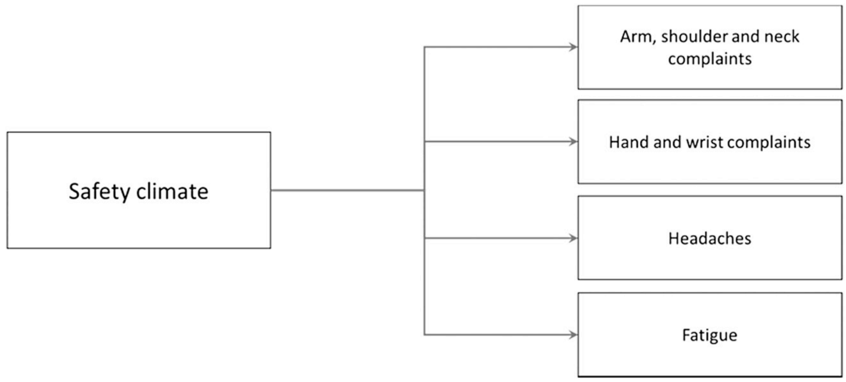

Fig. 1. Relationships to be explored in the study.

Table 1
Respondents' demographics.

Characteristics	Percent	N
Gender (male)	95.5	427
Position		
Fish farmer/technician	57.7	258
Operational manager	24.6	110
Service vessel worker	13.4	60
Other	4.3	19
Age		
≤30 years	28.6	128
31–40 years	22.6	101
41–50 years	27.7	124
≥51 years	21.0	94
Experience (fish farming)		
≤5 years	31.3	140
6–10 years	24.0	107
11–15 years	9.8	44
≥16 years	34.9	156

Table 2
Descriptive statistics for items.

Items		Mean	SD
Safety climate			
Q1	The company where I work takes safety seriously	4.43	0.89
Q2	The manning is sufficient to maintain the safety	3.73	1.03
Q3	The safety deputies' suggestions are taken seriously by the leaders	3.94	1.02
Q4	Information regarding unwanted events is utilised adequately to prevent recurrence	4.11	0.95
Q5	My manager appreciates that the employees take up safety issues	4.26	0.93
Q6	The equipment that I need to work safely is easily accessible	4.07	1.01
Q7	In practice, consideration to production is prioritised at the expense of safety	2.43	1.23
Q8	Inadequate maintenance has reduced the safety level	2.38	1.19
Q9	There are often parallel work operations proceeding that leads to dangerous situations	2.40	1.07
Q10	Sometimes I feel a pressure to continue working even though safety may be compromised	2.06	1.10
Q11	Due to fish welfare and fish escape considerations, safety procedures cannot always be followed	2.07	1.08
Q12	I have the necessary competence to handle my work tasks safely	4.52	0.71
Q13	I have received sufficient training to handle critical or dangerous situations	4.11	0.94
Q14	I get involved in acquisitions of new equipment	3.42	1.33
Q15	I participate in making new procedures	3.08	1.36
Q16	I get involved when new procedures are to be introduced	3.54	1.29
Health complaints			
Q17	To what extent have you experienced pain in the neck/shoulders/arms in the last 12 months?	2.61	1.29
Q18	To what extent have you experienced pain in the hands/wrists in the last 12 months?	1.98	1.15
Q19	To what extent have you been bothered by headaches in the last 12 months?	1.67	0.99
Q20	To what extent have you been bothered by fatigue in the last 12 months?	2.05	0.97

Table 2).

All of the safety climate items (Q1-Q16 in Table 2) were presented as statements with which the respondents were asked to indicate their level of agreement (e.g. 'The company where I work takes safety seriously'). The level of agreement was assessed on a five-point Likert scale, ranging from 'totally disagree' (=1), via the middle option 'neither agree nor disagree' (=3), to 'totally agree' (=5). A 'don't know/not relevant' option was also included. Respondents who selected this option on one or more of the items were included in the analysis but excluded in cases where all items within a factor were answered with the 'don't know/not relevant' option. This procedure resulted in the loss of only one respondent, thus leaving a usable net sample of 446 respondents. The average rate of 'don't know/not relevant' answers on the safety climate answers was 0.6%. None of these items had any missing answers.

As seen in Table 2, items Q1-Q6 and Q12-Q16 are positively worded. I.e. higher values are associated with a more positive safety climate. Seen in relation to the JD-R model (Bakker and Demerouti, 2007), these items represent safety resources (e.g. 'The manning is sufficient to maintain the safety'). Items Q7-Q11, however, are negatively worded. I.e. higher values are associated with a more negative safety climate. Seen in relation to the JD-R model, these items represent job demands (e.g. 'In practice, consideration to production is prioritised at the expense of safety').

Four items were used to cover self-reported health complaints (Q17-Q20 in Table 2). These items were presented as questions (e.g. 'To what extent have you been bothered by headaches in the last 12 months'), with which the respondents were given five response alternatives ranging from 'to a very small extent' (=1), to 'to a very great extent' (=5). A 'don't know/not relevant' option was also included. However, this option was not selected by any of the respondents and none of the items had any missing answers.

In order to reduce the number of safety climate items to a manageable size and to uncover the underlying safety climate factor structure, exploratory factor analysis (EFA) was conducted. The EFA method applied was principal component analysis (PCA) with varimax rotation. Factor loadings above or equal to 0.40 were considered sufficient to relate an individual item to a factor. The number of factors to extract was based on Kaisers criterion (Field, 2009). This means that factors with eigenvalues greater than or equal to 1 were retained. Internal consistency and reliability were assessed by Cronbach's alpha (Cronbach, 1951). Discriminant validity was assessed by correlations between factors (Netemeyer et al., 2003), and by inspecting the EFA for cross-loading items (Farrell, 2010).

3.2.2. Regression analysis

In order to test the hypothesised relationship between safety climate and health complaints, hierarchical multiple linear regression analysis (ordinary least squares) was conducted (Meyers et al., 2006). A separate analysis was conducted for each hypothesis. The hierarchical approach means that two models were run for each hypothesis. In the first model (named Model 1), a set of control variables were entered. These were the respondents' age and experience in the aquaculture industry (measured in years). In addition, an item related to physical strain ('Do you perform heavy lifting during work?') was included as a control variable. The respondents were given five response alternatives ranging from 'very seldom/never' (=1), to 'very often' (=5). In the second model (named Model 2), the safety climate factors were entered.

To assess the hypotheses, Model 2 as a whole was evaluated by the improvement in explained variance between each step (ΔR^2). Improvement in explained variance from one model to the next was tested with an F-test. A significant F-test means that the new variables entered significantly improve the prediction. The significance level was set to $\alpha = 0.05$. In addition to the F-test, the direction and the p-value of each individual regression coefficient was assessed by t-tests. This allows for a more detailed analysis than the F-test, because it enables the possibility of determining the effect of each safety climate factor.[2]

4. Results

4.1. Exploratory factor analysis

4.1.1. Factor extraction

Sixteen items were included in the factor analysis and the sample size was N = 476. This means that the general requirement of at least 10–15 respondents per item was fulfilled (Field, 2009). In addition, Kaiser–Meyer–Olkin's measure of sampling adequacy and Bartlett's test of sphericity showed satisfactory results (see notes in Table 3).

The application of Kaiser's criterion (i.e. eigenvalues greater than or equal to 1) resulted in a four-factor solution. From Table 3, it is clear that all 16 items had satisfactory loadings on a factor to be retained in the four-factor solution, i.e. all factor loadings were above 0.40. Moreover, none of the items had loadings above 0.40 on more than one factor. This indicates a simple factor structure without cross-loadings. Based on a visual inspection of the scree plot, a three-factor solution was also tested. This, however, resulted in several cross-loadings. Thus, the four-factor solution was retained. This factor structure accounted for 61.5% of the total variance. An EFA with the four health complaint items included was also tested. These items loaded on a fifth factor. Not surprisingly, this indicates that the four health complaint items are related and that they together form a health complaints factor. However, it was decided to analyse all health complaint items separately in the following regression analyses to explore possible different relationships between safety climate and the different types of health complaints. The four safety climate factors retained were labelled as follows:

- *Safety priority*: The factor consists of six items related to the respondents' perceptions of the company's priority of safety. The first item (Q1) is general, whereas the remaining five are related to specific topics such as manning, follow-up of unwanted events and accessibility of necessary equipment. After varimax rotation, this factor accounted for 21.3% of the variance. The factor loadings varied from 0.575 to 0.770.
- *Work pressure*: The factor consists of five items related to the respondents' perceptions of the company's priority production and efficiency at the expense of safety. Again, the first item (Q7) is general, whereas the remaining four are related to specific topics such as inadequate maintenance, parallel work operations and fish welfare. After varimax rotation, this factor accounted for 16.8% of the variance. The factor loadings varied from 0.559 to 0.753.
- *Safety involvement*: The factor consists of three items related to the respondents' perceptions of involvement in safety decisions. The three items cover topics such as involvement in acquisition of new equipment, creation of new procedures and introduction of new procedures. After varimax rotation, this factor accounted for 9.9% of the variance. The factor loadings varied from 0.733 to 0.880.
- *Safety competence*: The factor consists of two items related to the respondents' perceptions of one's own safety competence and the company's priority of safety training. After varimax rotation, this

Table 3
Exploratory factor analysis: PCA, Varimax with Kaiser normalisation.

Items		Factor loadings				Comm.
Q1	The company where I work takes safety seriously	0.770				0.632
Q2	The manning is sufficient to maintain the safety	0.575				0.482
Q3	The safety deputies' suggestions are taken seriously by the leaders	0.754				0.685
Q4	Information regarding unwanted events is utilised adequately to prevent recurrence	0.762				0.610
Q5	My manager appreciates that the employees take up safety issues	0.672				0.582
Q6	The equipment that I need to work safely is easily accessible	0.627				0.540
Q7	In practice, consideration to production is prioritised at the expense of safety		0.559			0.466
Q8	Inadequate maintenance has reduced the safety level		0.671			0.504
Q9	There are often parallel work operations proceeding that leads to dangerous situations		0.753			0.586
Q10	Sometimes I feel a pressure to continue working even though safety may be compromised		0.744			0.607
Q11	Due to fish welfare and fish escape considerations, safety procedures cannot always be followed		0.712			0.552
Q12	I have the necessary competence to handle my work tasks safely			0.817		0.720
Q13	I have received sufficient training to handle critical or dangerous situations			0.823		0.747
Q14	I get involved in acquisitions of new equipment				0.733	0.648
Q15	I participate in making new procedures				0.880	0.800
Q16	I get involved when new procedures are to be introduced				0.747	0.672
Rotated sum of squared loadings (% of variance)		21.26	16.81	13.53	9.85	
Eigenvalues (Total)		5.73	1.70	1.33	1.07	

Bartlett's test of sphericity (approx. Chi-square) = 2,373 ($p < 0.001$). Kaiser-Meyer-Olkin measure of sampling adequacy = 0.888. Factor loadings below 0.40 are suppressed.

[2] All analyses were conducted with SPSS version 25.0 software.

factor accounted for 13.5% of the variance. The factor loadings varied from 0.817 to 0.823.

4.1.2. Discriminant validity, internal consistency and reliability

Table 4 presents correlations between the four factors and, on the diagonal, the Cronbach's alphas within the factors. High correlations (higher than ± 0.7) between factors that are supposed to differ are an indication of low discriminant validity. Low or moderate correlations (lower than ± 0.7) are an indication of high discriminant validity (Netemeyer et al., 2003). As appears from Table 4, all correlations between the four factors are low or moderate. This, combined with the fact that no items loaded on more than one factor in the EFA (Farrell, 2010), indicates high discriminant validity. The negative correlations between work pressure and the other factors are expected, as all items included in the factor are negatively loaded whereas the items included in the other factors are positively loaded.

Regarding the alpha scores, Nunnally (1978) argues that alphas greater than 0.70 indicate adequate internal consistency and reliability. As shown on the diagonal in Table 4, all alpha scores are greater than 0.70, with the exception of safety competence (0.62). As noted by Cortina (1993), however, the Cronbach's alpha is not only a function of the item intercorrelations, but also a function of the number of items in the factor. Hence, a small number of items will lower the alpha score, and therefore the alpha scores must be interpreted with consideration to the number of items. Thus, taking the number of items of the safety competence factor into consideration, the alpha score was considered to be within an acceptable limit.

4.2. Regression analyses: test of hypotheses

The results from the regression analyses are presented in Tables 5–8. As described in the method section, the regressions analyses were conducted hierarchically in two steps (model 1 and model 2), where only the control variables are included in model 1, whereas the safety climate factors are entered in model 2. This allows for testing the separate effect of safety climate (controlled for the effect of age, experience and frequency of heavy lifting).

Table 5 presents the regression analysis of neck, shoulder and arm complaints. As can be seen in model 1, where only the control variables are entered, the respondents' age and frequency of heavy lifting are positively and significantly related to neck, shoulder and arm complaints. This means that the older the respondents, the more neck, shoulder and arm complaints are experienced. Similarly, the more the work includes heavy lifting, the more neck, shoulder and arm complaints are experienced. The standardised regression coefficient (β) is higher for heavy lifting (0.340) than that of age (0.183). The effect of both age and heavy lifting is still significant, but reduced in model 2, where safety climate is added. Moreover, the explained variance increases significantly to 19.9%. The F-test, the F-value (Δ) and the corresponding p-value – reveals that adding the safety climate factors to the model significantly increases the explained variance. This means that the regression analysis gives support to Hypothesis 1, which postulated that arm, shoulder, neck complaints will be negatively related to safety climate. This is supported by the fact that each safety climate factor is in the expected negative direction, with the exception of work pressure, which as expected is in the positive direction (given that all items included in the factor are negatively loaded). However, the t-tests for each factor show that safety involvement is the only safety climate factor that has a significant effect. This means that respondents who are involved in the acquisition of new equipment and in the making and introduction of new procedures experience fewer neck, shoulder and arm complaints than respondents who are less involved. The standardised regression coefficient (β) shows that the effect of safety

Table 4
Pearson's correlations between factors; Cronbach's alpha on the diagonal.

Construct	Items	1	2	3	4
1. Safety priority	6	(0.853)			
2. Work pressure	5	−0.517	(0.766)		
3. Safety involvement	3	0.518	−0.306	(0.776)	
4. Safety competence	2	0.430	−0.303	0.242	(0.619)

Table 5
Linear regression: Experience of neck, shoulder, arm complaints with unstandardised (B) and standardised (β) regression coefficients.

Model		B	SE B	β
1.	Constant	0.699	0.264	
	Age	0.020	0.006	0.183**
	Experience	0.008	0.008	0.060
	Heavy lifting	0.391	0.051	0.340*
2.	Constant	1.885	0.613	
	Age	0.018	0.006	0.172*
	Experience	0.009	0.007	0.072
	Heavy lifting	0.291	0.052	0.253*
	Safety priority	−0.069	0.101	−0.040
	Work pressure	0.113	0.079	0.071
	Safety competence	−0.006	0.086	−0.003
	Safety involvement	−0.252	0.059	−0.215*
F-value (Δ)		9.320*		
Overall adjusted R^2		0.199		
Δ R^2		0.067		

*p < 0.01. **p < 0.05.

Table 6
Linear regression: experience of hand, wrist complaints with unstandardised (B) and standardised (β) regression coefficients.

Model		B	SE B	β
1.	Constant	1.109	0.250	
	Age	0.012	0.006	0.127**
	Experience	−0.004	0.007	−0.037
	Heavy lifting	0.165	0.049	0.160*
2.	Constant	2.048	0.587	
	Age	0.011	0.006	0.113
	Experience	−0.002	.007	−0.021
	Heavy lifting	0.078	.050	0.076
	Safety priority	−0.074	.097	−0.048
	Work pressure	0.179	.076	0.126**
	Safety competence	−0.073	.083	−0.045
	Safety involvement	−0.139	.056	−0.133**
F-value (Δ)		7.528*		
Overall adjusted R^2		0.080		
Δ R^2		0.062		

*p < 0.01. **p < 0.05.

Table 7
Linear regression: experience of headache with unstandardised (B) and standardised (β) regression coefficients.

Model		B	SE B	β
1.	Constant	1.736	0.214	
	Age	−0.014	0.005	−0.171*
	Experience	0.013	0.006	0.129**
	Heavy lifting	0.124	0.042	0.140*
2.	Constant	2.154	0.504	
	Age	−0.015	0.005	−0.186*
	Experience	0.014	0.006	0.138**
	Heavy lifting	0.054	0.043	0.061
	Safety priority	−0.073	0.083	−0.055
	Work pressure	0.183	0.065	0.151*
	Safety competence	0.002	0.071	0.002
	Safety involvement	−0.096	0.049	−0.107**
F-value (Δ)		6.677*		
Overall adjusted R^2		0.079		
Δ R^2		0.055		

*p < 0.01. **p < 0.05.

Table 8
Linear regression: experience of fatigue with unstandardised (B) and standardised (β) regression coefficients.

Model		B	SE B	β
1.	Constant	1.508	0.209	
	Age	−0.002	0.005	−0.030
	Experience	0.011	0.006	0.114
	Heavy lifting	0.191	0.041	0.220*
2.	Constant	1.103	0.483	
	Age	−0.004	0.005	−0.047
	Experience	0.011	0.006	0.115
	Heavy lifting	0.116	0.041	0.134*
	Safety priority	0.004	0.080	0.003
	Work pressure	0.304	0.063	0.255*
	Safety competence	0.079	0.068	0.058
	Safety involvement	−0.118	0.046	−0.134**
F-value (Δ)	10.970*			
Overall adjusted R^2	0.125			
ΔR^2	0.086			

*p < 0.01. **p < 0.05.

involvement (−0.215) is almost as powerful as the effect of heavy lifting (0.253).

Table 6 presents the regression analysis of hand and wrist complaints. As shown in model 1, the respondents' age and frequency of heavy lifting are positively and significantly related to hand and wrist complaints. This means that hand and wrist complaints increase with age, and that the more the work includes heavy lifting, the more hand and wrist complaints are experienced. The standardised regression coefficient (β) for heavy lifting (0.160) is slightly higher than that of age (0.127). When safety climate is added in model 2, the effect of both age and heavy lifting is reduced and insignificant. Further, the explained variance increases significantly to 8.0%. The F-test shows that adding the safety climate factors to the model significantly increases the explained variance. This means that the regression analysis gives support to Hypothesis 2, which postulated that hand and wrist complaints will be negatively related to safety climate, i.e. the more positive the safety climate, the fewer the hand and wrist complaints. This is supported by the fact that each safety climate factor is in the expected direction. The t-tests for each factor show that work pressure and safety involvement have a significant effect, whereas safety priority and safety competence do not. This means that employees who work in a company that prioritises production and efficiency at the expense of safety experience more hand and wrist complaints than employees who work in a company that puts safety before production and efficiency. Furthermore, employees who are involved in the acquisition of new equipment and in the making and introduction of new procedures experience fewer hand and wrist complaints than respondents who are less involved. The standardised regression coefficient (β) shows that the effect of work pressure (0.126) and safety involvement (−0.133) are more powerful than the effect of any of the control variables.

Table 7 presents the regression analysis of the dependent variable headache. As shown in model 1, the respondents' age is negatively and significantly related to headaches, while experience and frequency of heavy lifting are positively and significantly related to headaches. The effect of age and experience is still significant in model 2, where safety climate is added. Moreover, the explained variance increases significantly to 7.9%. Again, the F-test shows that adding the safety climate factors to the model significantly increases the explained variance. This means that the regression analysis gives support to Hypothesis 3, which postulated that headaches will be negatively related to safety climate. Akin to the analysis of hand and wrist complaints, the t-tests for each factor show that work pressure and safety involvement have a significant effect, whereas safety priority and safety competence do not. This means that employees who work in a company that prioritises production and efficiency at the expense of safety experience more headaches than employees who work in a company that puts safety before production and efficiency. Further, employees who are involved in the acquisition of new equipment and in the making and introduction of new procedures experience fewer headaches than respondents who are less involved. The standardised regression coefficient (β) shows that the effect of work pressure (0.151) and safety involvement (−0.107) are slightly less powerful than the effect of age, more powerful than the effect of heavy lifting, and roughly as powerful as the effect of experience.

Table 8 presents the regression analysis of the dependent variable fatigue. As can be seen in model 1, the frequency of heavy lifting is positively and significantly related to fatigue. This means that the more the work includes heavy lifting, the more fatigue is experienced. The effect of heavy lifting is still significant, but reduced in model 2, where safety climate is added. Moreover, the explained variance increases to 12.5%. The F-test shows that adding the safety climate factors to the model significantly increases the explained variance. This means that the regression analysis gives support to Hypothesis 4, which postulated that fatigue will be negatively related to safety climate. This is supported by the fact that each safety climate factor is in the expected direction. Similar to the analysis of hand and wrist complaints and headaches, the t-tests for each factor show that work pressure and safety involvement have a significant effect, whereas safety priority and safety competence do not. This means that employees who work in a company that prioritises production and efficiency at the expense of safety experience more fatigue than employees who work in a company that puts safety before production and efficiency. Furthermore, employees who are involved in the acquisition of new equipment and in the making and introduction of new procedures experience less fatigue than respondents who are less involved. The standardised regression coefficient (β) shows that the effect of work pressure (0.255) is far more powerful than the effect of any of the control variables. The effect of safety involvement (−0.134) is equal to the effect of heavy lifting.

Overall, the regression analyses give support to all four hypotheses. This implies that the analyses verify the assumption that health complaints are negatively related to safety climate, i.e. the more positive the safety climate, the fewer the health complaints and vice versa. However, the effect of safety climate is moderate (indicated by moderate ΔR^2 values). Further, not all safety climate factors are related to health complaints. Safety priority and safety competence had no significant effect in any of the analyses. In contrast, safety involvement had a significant negative effect in all of the analyses and work pressure had a significant positive effect in three of the four analyses.

To investigate potential problems with high multicollinearity (i.e. the occurrence of high intercorrelations among independent variables), the tolerance statistic was examined in all regression models. The minimum tolerance value identified was 0.53. This is well above the critical value of 0.20 (Field, 2009). To investigate the presence of highly influential cases, Cook's distance (D_i) was examined for each case. The maximum D_i was 0.05, which is well below the cut-off value of 1 (Field, 2009).

5. Discussion

5.1. Key findings

It has long been recognised that safety climate is a significant contributor to the safety performance of high-risk organisations. Some recent studies have also indicated that negative safety climates may contribute to workers' health complaints. Accordingly, the present study assumed a negative relationship between safety climate and health complaints, i.e. the more positive the safety climate, the fewer the health complaints and vice versa. Four different types of health complaints were analysed: (1) arm, shoulder, neck complaints; (2) hand and wrist complaints; (3) headaches; and (4) fatigue. In sum, the regression analyses gave support to the assumption that safety climate is negatively related to health complaints, i.e. all four types of health complaints were significantly and moderately related to safety climate. However, the effect of safety climate differed slightly. Controlled for age, experience and heavy lifting, the effect of safety climate was greatest for fatigue ($\Delta R^2 = 0.086$) and lowest for headaches ($\Delta R^2 = 0.055$).

Furthermore, it should be emphasised that not all of the safety climate factors analysed were significantly related to health complaints. Safety priority and safety competence were not related to any of the health complaints analysed. This means (1) that the employees' perceptions of topics such as manning, follow-up of unwanted events and accessibility of necessary equipment, and (2) employees' perceptions of their own safety competence and the company's priority of safety training were not related to health complaints. On the other hand, safety involvement was significantly and negatively related to health complaints in all of the analyses, whereas work pressure was significantly and positively related to health complaints in three of the four analyses. This means (3) that employees who participate in safety-related decisions (such as the acquisition of new equipment, creation of new procedures and introduction of new procedures) have fewer health complaints than employees who are not allowed to participate in such decisions. In addition, (4) employees who perceive that production and efficiency are prioritised at the expense of safety have more health complaints than those who perceive that safety is given more weight than production and efficiency. The effect of safety involvement and work pressure, with standardised regression coefficients (β), is summarised in Fig. 2.

The fact that the two safety climate factors of safety involvement and work pressure are related to health complaints is consistent with findings in associated research. As already described, Golubovich et al. (2014) review of previous studies indicates that thematically related factors such as work load, time pressure and autonomy are acknowledged risk factors for MSD. Furthermore, Arcury et al. (2012) study among farmworkers found that negative safety climates are associated with increased risk of musculoskeletal discomfort. Regarding our specific findings related to fatigue and headache, Hystad et al. (2013) study of seafarers in the offshore oil and gas industry found that negative safety climates are correlated with mental fatigue, physical fatigue and lack of energy. It should also be noted that the findings are in line with studies of the relationship between JD-R and health complaints (e.g. Airila et al., 2014; Glaser et al., 2015; Sprigg et al., 2007). The results demonstrate that job demands, in the form of work pressure, are positively related to health complaints, and that resources, in the form of safety involvement, are negatively related to health complaints.

The control variable age was positively related to neck, shoulder and arm complaints and hand and wrist complaints. This is in line with previous studies that have found that the prevalence of MSD increases with age (Holmström and Engholm, 2003; Kinge et al., 2015), possibly associated with accumulated mechanical strain over time and ageing processes. Age was negatively related to headache, meaning that headache decreased with age. This is consistent with population studies (e.g. Rasmussen et al., 1991; Jensen and Stovner, 2008), but there are no clear explanations for the negative associations observed.

5.2. Implications, limitations and further work

In general, the results from this study support that psychosocial factors may increase the risk of MSDs, headaches and fatigue. The effects of safety climate were significant in general, and the effects of the safety climate factors were in some instances on the same level or higher than the control variables age, experience and heavy lifting. Safety climate has rarely been studied in relation to workplace health (Bentley and Tappin, 2010). Thus, psychosocial factors and especially safety climate should be explored further as a supplement to the research on individual and biomechanical risk factors, of which the control variables constitute examples.

The relationships between safety climate and occupational health complaints indicate the possible existence of a supplementary managerial pathway for the prevention of occupational health issues. Traditional ergonomic measures to reduce strain and automatisation to remove harmful and straining work tasks are clearly important and address some immediate causes of occupational health issues. Our results also support the notion that work-related health problems may be prevented when work is organised in such a way that unhealty work pressure is reduced, and by involving employees in decisions related to safety. As noted above, this is also in line with previous research on the relationship between JD-R and health complaints.

Based on the content of the safety climate factors, and related to the aquaculture industry, concrete reduction of work pressure might involve unequivocally prioritisation of personnel safety by management, also when fish welfare is threatened, or in fish escape situations, and avoid parallel work operations that may lead to dangerous situations. Further, management can improve safety participation by involving workers in procedure development and in acquisition of new equipment. As safety climate factors, work pressure and lack of safety involvement can act as a stressors, eliciting frustration and increase MSDs (Golubovich et al., 2014). In addition to such concrete measures, managers in aquaculture might benefit from improving the safety culture in general for reducing MSDs. There are several approaches for this. 'The cultural ladder (Hudson, 2007) is for example an instrumental tool-box developed for the petroleum industry, involving a mapping of the cultural level for organisations, and measures for 'climbing the cultural ladder'. Another example is Action Research, which is an interpretive approach, based on extensive worker participation and researcher involvement in safety culture development (Solem and Kongsvik, 2013).

As is the case in many other studies that use questionnaire surveys,

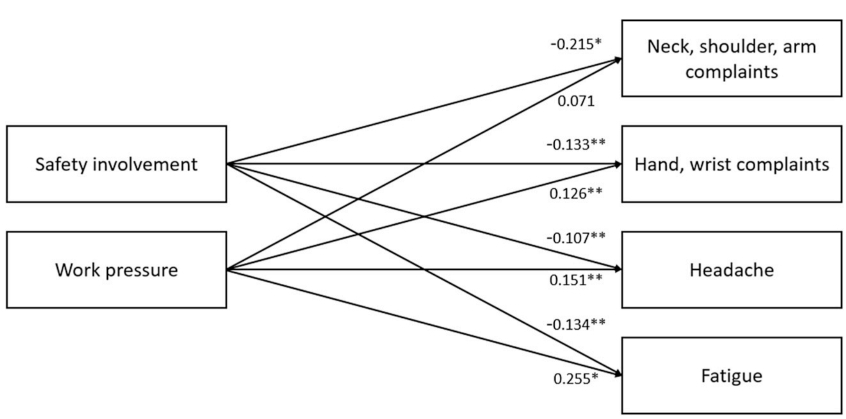

Fig. 2. Summary of the association between safety involvement and work pressure and (1) neck, shoulder, arm complaints, (2) hand wrist complaints, (3) headaches, and (4) fatigue, with standardised (β) regression coefficients (*$p < 0.01$. **$p < 0.050$).

common method bias (Podsakoff et al., 2003) might represent a limitation. The same questionnaire was used both to measure safety climate and reveal health complaints, which could mean that some of the associations are spurious and caused by the method itself. For example, a common underlying factor such as general content or discontent with the work or the working environment might explain the associations found. In addition, regression analyses do not prove any casual relationships between variables, only co-variation. We have no indications of biases in the data material, but future studies should strive to apply independent data sources so that the associations could be validated further. This may include health record data in addition to survey methods. Larger samples and samples from other occupational groups will also be preferable in later research. A longitudinal research design, for example by obtaining data on safety climate and MSDs before and after a safety climate intervention, could also provide a stronger argument for cause-effect relationships.

The present study includes individual control variables (age and experience) and a control variable for physical job demands (heavy lifting). According to Golubovich (2014: 758), some studies fail to apply such controls, which might explain some of the inconsistent findings regarding associations between psychosocial factors and work-related MSDs. It is recommended that future studies also involve control variables as well as intermediate variables. This might reveal and broaden the knowledge on different mechanisms that can produce the association between safety climate and health.

Workers in the aquaculture industry seem to be well-suited for studying the association between safety climate and health problems. The work is organised in fairly stable groups in which a distinct safety climate can develop, and the work is also physically demanding and involves considerable strain. A significant proportion of workers in this industry report health problems (Thorvaldsen et al., 2017). Although a few other studies exist that have identified some of the same associations (Arcury et al., 2012; Golubovich et al., 2014; Swanberg et al., 2017), further studies should involve other industries and types of work as well as different locations in order to ascertain whether the relationships can be validated across different contexts.

It should also be added that the current study includes a rather limited set of health complaints. For example, within the group of musculoskeletal disorders, several other parts of the musculoskeletal system are known to be vulnerable to work-related stressors, including lower limbs and the back. Thus, the results of this study should be interpreted in light of the limited set of health complaints that it deals with. For a more comprehensive understanding of the relationship between safety climate and health complaints, future studies should involve other types of health complaints as well.

6. Conclusions

Safety climate studies traditionally focus on the relationship between safety climate and some type of safety performance, such as safety behaviour and occupational accidents. However, some recent studies indicate that there might also be a relationship between safety climate and health complaints (e.g. Golubovich et al., 2014). Based on a survey among sharp-end workers in the Norwegian aquaculture industry, the objective of the present study was to explore this relationship further. Four types of health complaints were analysed: (1) arm, shoulder and neck complaints; (2) hand and wrist complaints; (3) headaches; and (4) fatigue. The analyses revealed that the safety climate factor 'safety involvement' was negatively related to all four types of health complaints, whereas the safety climate factor 'work pressure' was positively related to all but neck, shoulder, arm complaints. The findings demonstrate that safety climate should be taken into consideration when it comes to health effects. This might provide a basis for preventative strategies that can supplement traditional counterparts.

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Declaration of competing interest

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