

## Summary

# Organisational influences on occupational safety in Norwegian maritime transport

*TOI Report 1501/2016  
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Oslo 2016 80 pages English language*

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*This study employs three methods to survey organisational influences on occupational safety in Norwegian maritime transport. Our analyses indicate that organisational safety culture is the most important organisational factor, predicting all our measures of occupational safety: injuries, risk perception, fatigue and procedure violations. We also found organizational safety culture to be a key predictor of (other) organisational factors, e.g. work pressure, working conditions and procedures describing hazards. Thus, future research should examine the preconditions of good maritime safety culture, in order to form a basis for developing safety culture interventions on board Norwegian vessels. The study has also found interesting relationships between organisational safety culture, manning level and working conditions which should be followed up in future research. Data from the small-scale survey indicates that respondents on vessels with low manning (3-4 people) score lower on many of the variables measuring occupational safety and organisational factors. These vessels have more personal injuries, and crew members rate the safety level and the safety culture as lower than crew members on other vessels. Future research should examine this further to facilitate measures to improve safety on board these vessels. It is important to note that we do not examine whether manning levels are too low on these vessels, we merely compare occupational safety and organisational factors. Finally, we also found that factors that are not organisational are important for the occupational safety of the seafarers in our sample. Both the age groups of the respondents and their positions/ lines of work influence several different aspects of occupational safety.*

## Background and aims

Sea transport is central to world trade, as it carries about 90 % of internationally traded produce (Alderton & Winchester 2002). Sea transport dominates long distance goods transport in Norway, where it constitutes about 81 % of the import, measured in tonnes, including passenger ferries, and about 73 % of the export measured in tonnes, including ferries and excluding crude oil and natural gas (St. melding nr. 31 2003-2004).

According to Nævestad, Elvebakk, Phillips, Bye and Antonsen (2015), there were on average 15 killed and 424 injured annually on Norwegian ships in the period 2004-2013. In the present study we examine how occupational safety on board Norwegian vessels is influenced by organisational factors.

The study focuses on the following organisational factors, as these have been highlighted as important in previous research: 1) Organisational safety culture, 2) Manning, work load, and stress, 3) Working conditions and rest, and 4) Safety management system. The present study attempts to build on this research by focusing on organizational influences on occupational safety on vessels registered in the Norwegian Ordinary Ship Register (NOR).

The aims of the study are to:

- 1) Survey organizational factors and other factors influencing occupational safety on Norwegian vessels.
- 2) Survey variables influencing organizational factors in order to examine relationships between them and point to the most important factors influencing occupational safety on Norwegian vessels.

These aims are important, as obtaining knowledge on these factors is a prerequisite of implementing preventive measures to improve occupational safety. This report is part of a larger research project: “Work-related accidents in road, sea and air transport: prevalence, causes and measures” lasting for three years, from March 2014 to March 2017.

## **Key concepts and measures**

In this study, *occupational safety* refers to the following variables:

- 1) Personal injuries occurring while at work (1 item).
- 2) Perception of risk related to work place hazards (2 items).
- 3) Safety compromising fatigue (1 item).
- 4) Procedure violations and lacking use of procedures (index summing up 3 items).

*Organisational factors* are defined as formal and informal aspects of seafarers’ work organizations, which may influence occupational safety. In this study, organisational factors refer to the following variables:

- 1) Organisational safety culture (index summing up 18 items).
- 2) Manning level on vessels (1 item).
- 3) Work pressure (1 item).
- 4) Demanding working conditions (index summing up 3 items).
- 5) Working hours and rest on board (3 items).
- 6) Safety management system (2 items on work procedures and risk analyses)

We also examine the influence of “*non-organisational factors*” on occupational safety (aim 1) and on organizational factors (aim 2):

- 1) Seafarers’ position/line of work (1 item).
- 2) Seafarers’ age (1 item).
- 3) Vessel type (1 item).
- 4) Vessel age (1 item).
- 5) Number of port calls per week (1 item).

## **Methods**

The data were originally collected for a study comparing safety and organisational factors on NOR vessels and foreign-flagged vessels (Nævestad 2016). In the present report, we choose however to take a closer look at the organisational factors influencing the occupational safety of the seafarers (N=180) on board NOR registered vessels in our sample. The study employed three different methods:

- 1) Qualitative interviews. We conducted qualitative interviews with 10 sector experts from employer organisations, employee organisations, authorities and other organisations involved in maritime safety.
- 2) Reference group meeting. We were provided with useful information and viewpoints in a reference group meeting held at the Institute of Transport Economics, March 27<sup>th</sup>, 2014. Results from this meeting are presented together with results from the interviews.
- 3) Small-scale survey. We present results from a small-scale survey (N=180) with seafarers who were recruited through “Kystrederiene”, an employer organisation for shipping companies based in Norway.

## **Occupational safety**

The study includes four measures of occupational safety, and personal injury is the most important measure. Our survey indicates that 17 % of our respondents (N=180) had been injured in their work on board in the course of the last two years.

We found that the following variables influenced seafarers’ risk of injuries on board:

- 1) Age: The older the seafarers are, the less likely they are to have been injured in the last two years.
- 2) Position: Deck crew/apprentices were more inclined to be injured than others
- 3) Vessel type: crew members of well vessels were more inclined to be injured
- 4) Manning level: The higher manning level, the lower was the risk of personal injuries
- 5) Organisational safety culture: The better safety culture the respondents report, the less likely it is that they have had an injury in the last two years.

Interestingly, we see that only the two latter variables, manning level and organisational safety culture are what we refer to as organisational factors. The three former variables predicting seafarers’ risk can be attributed to individuals or vessels.

We found, however, that respondents’ risk perceptions largely were predicted by organisational factors. The following variables influenced respondents’ perception of risk:

- 1) Respondents’ experiences of safety-compromising fatigue, 2) Perception of work pressure, 3) Organisational safety culture, 4) Experiences of demanding working conditions (i.e. shift delays, 16-hours of continuous work and interrupted rests).

The research literature indicates that fatigue is an important safety risk in the maritime sector, and that is rooted in framework, organisational and working conditions, as well as individual characteristics and life outside of work. Seafarers share several important work characteristics influencing fatigue, for instance long working hours and sleep disturbances, due to for instance motion, noise and night work.

Respondents were asked to rate their agreement with the statement: “Sometimes I am so tired during working hours that safety is compromised”. We conducted analyses to examine factors influencing respondents’ experiences of safety-compromising fatigue. First, we found that the older seafarers are, the less likely they are to report of safety-compromising fatigue. Second, deck personnel are more likely to be fatigued in manners that may compromise safety. Third, we found that having a good safety culture decreases the risk of safety-compromising fatigue. Finally, we found that respondents’ experiences with demanding working conditions is the most important predictor of safety-compromising fatigue. Thus, we see that respondents’ experiences with safety compromising fatigue is influenced by both individual factors and organisational factors.

### Safety culture is a key organisational factor

We made an organisational safety culture index, consisting of 18 questions from the Global Aviation Information Network (GAIN)-scale (GAIN 2001), and we used this in our survey. Our analyses indicate that organisational safety culture is the most important organisational factor, predicting all of the aspects of occupational safety: 1) Personal injuries, 2) Worry about risk, 3) Assessment of the safety of the work place situation, 4) Safety compromising fatigue and 5) Lacking procedure use and procedure violations.

We also found organizational safety culture to be a key predictor of (other) organisational factors: 6) Work pressure, 7) Demanding working conditions and 8) Procedures describing hazards, see figure S.1.

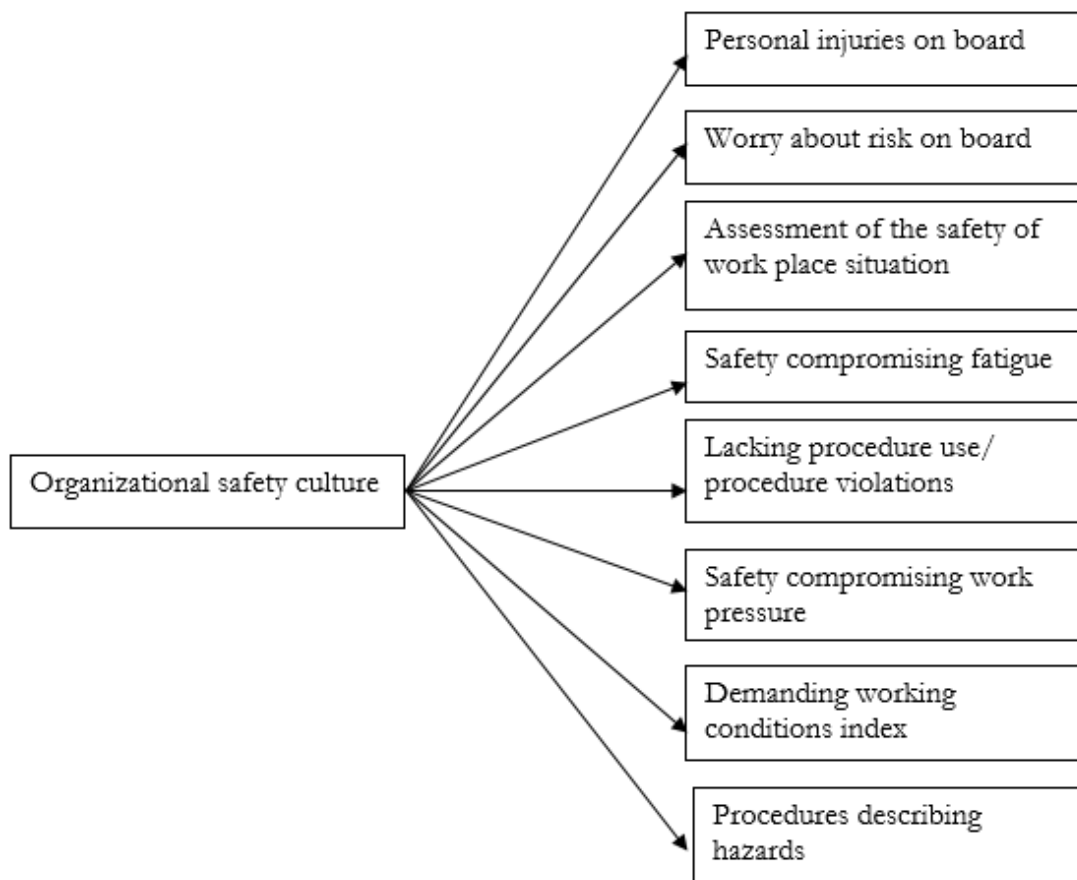


Figure S.1: Relationships between organisational safety culture and variables measuring occupational safety and organisational factors.

The importance of organisational safety culture for several safety outcomes, was also highlighted in the research literature and in the interviews. Culture, attitudes, knowledge, skills and risk understanding are factors that are important when it comes to explaining safety behaviour among crew members on board ships and the ship accident risk.

## Manning level

Respondents were asked several question about the manning level on board their vessels. Our sample is too little for comparison and generalization, as we analysed manning numbers based on the unique vessels in our sample (calculations were made based on the captains in the sample). Keeping this in mind, we saw that the average manning level on vessels less than 500 dwt is 4.3, while it is 5.9 on vessels between 500 and 3,000 dwt.

Above, we saw that manning level predicts seafarers' risk of personal injuries: The higher manning level, the lower was the risk of personal injuries. Although differences between the shares are not statistically significant, vessels manned by 3-4 people had the highest share of crew members who had been injured in the last two years (26 %). The corresponding numbers for vessels manned by 5-6 people was 20 %, while it was 7 % for vessels manned by 7-8 people.

Data from the small-scale survey indicates that the vessels with low manning (3-4 people) score lower on many of our variables measuring occupational safety and organisational factors. Seafarers on vessels with a manning of 3-4 people rate the safety level of their work place as lower than other respondents (Mean: 7.3 versus 8.6 points) ( $P=0.00$ ). Seafarers on vessels with a manning of 3-4 people also rate their organisational safety culture as lower than other respondents. Figure S.2 illustrates the relationship between these three variables.

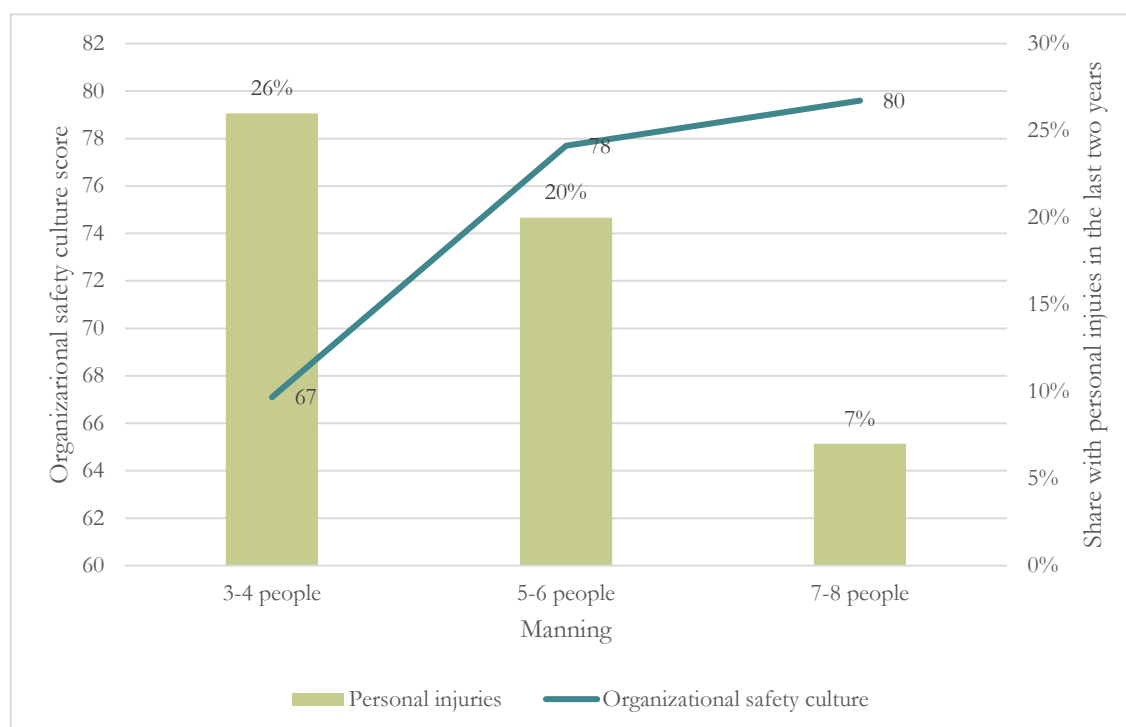


Figure S.2: Organisational safety culture scores (scale from 18 to 90 points) and shares of seafarers who have been injured on board in the last two years on vessels with different manning levels: 3-4 people ( $N=19$ ), 5-6 people ( $N=113$ ) and 7-8 people ( $N=45$ ).

Although not all results were statistically significant, we saw that seafarers working on board vessels manned by 3-4 people reported more pressure to work even though it is not perfectly safe, they agreed less that they get sufficient sleep and rest on board, they experience more often demanding working conditions, and they report of higher levels of safety-compromising fatigue. Future research should examine occupational safety and organisational factors on vessels with low manning (3-4 people) in order to be able to implement measures to improve safety. We expand on this below.

When interpreting results, it is important to note that numbers are small in the sample of vessels manned by 3-4 people (N=19), although results indicate a tendency of higher scores on variables measuring occupational safety and organisational factors with increasing values on the manning level variable. Thus, results must be interpreted with caution and further research is required to examine the importance of manning level for occupational safety and organisational factors. We return to this below.

### Demanding working conditions and work pressure

Above, we saw that demanding working conditions (i.e. experiences of shift delays, 16-hours of continuous work and interrupted rests) was the most important predictor of safety compromising fatigue.

We made an index measuring respondents' demanding working conditions and we analysed the factors influencing this index. First, we found that older respondents are less inclined to experience these things. Second, being a captain makes seafarers more prone to demanding working conditions. Third, we saw that higher manning levels reduced the occurrence of these experiences, until organisational safety culture was included in the analysis. Figure S.3 illustrates the relationship between these three variables. Finally, the most important predictor of respondents' demanding working conditions was organisational safety culture: a good safety culture reduced the occurrence of these experiences.

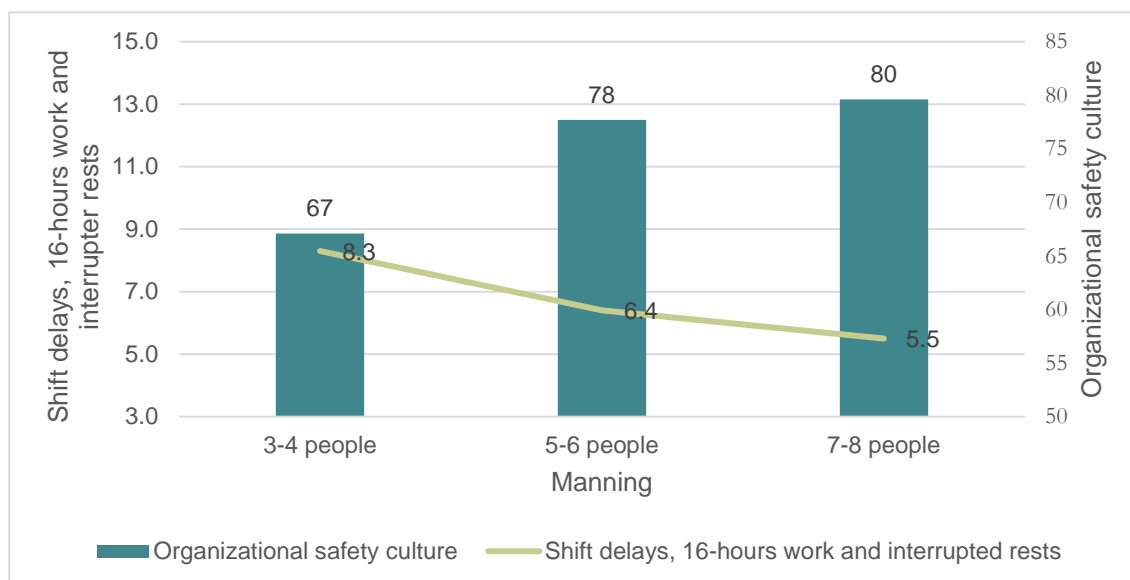


Figure S.3: Organisational safety culture scores (scale from 18 to 90 points) demanding working conditions index (scale from 3 to 21 points) on vessels with different manning levels: 3-4 people (N=19), 5-6 people (N=113) and 7-8 people (N=45).

Results indicate a close relationship between work pressure, demanding working conditions and organisational safety culture. Respondents were asked to rate their agreement with the statement: “Sometimes I feel pressured to continue working, even if it is not perfectly safe”. We conducted analyses to examine factors influencing this variable, and found that organisational safety culture was the strongest predictor. A good organisational safety culture seems to reduce unsafe work pressure. We also found a relationship between unsafe work pressure and respondents’ experiences of demanding working conditions. The more often respondents experience demanding working conditions, the more they agree with the statement “Sometimes I feel pressured to continue working, even if it is not perfectly safe”.

## **Age and position influence several aspects of occupational safety**

We also found that factors that are not organisational are important for the occupational safety of the seafarers in our sample. The age groups of the respondents, for instance, influence several different aspects of occupational safety. We found a relationship between age and personal injuries; the older respondents are, the less likely they are to have been personally injured in the last two years. We also found a relationship between age and fatigue; older seafarers (>60 years) are less likely to have experienced safety-compromising safety, perhaps as they reported of less demanding working conditions.

Our analyses also indicate that respondents’ positions/lines of work influence several different aspects of occupational safety. Deck crew and apprentices were more likely to have experienced personal injuries in the last two years. Second, senior crew members (Captain, Deck Officer, Chief Engineer) were more worried about the risks on board than other crew members. Third, engine personnel agreed less than other groups that there were job descriptions/ procedures describing hazards of work assignments. Fourth, we found a relationship between line of work and fatigue; engine personnel were more inclined to sometimes be so tired during working hours that safety is compromised than other groups on board. Finally, captains were more inclined to have experienced demanding working conditions.

## **Questions for further research**

### **Which factors influence organisational safety culture?**

We conclude that organisational safety culture is the most important safety predictor in our sample, predicting, e.g. injuries, risk perception, fatigue, procedure violations, work pressure, working conditions. Thus, if we know how to facilitate good safety culture on Norwegian vessels, we may be able to influence several safety relevant outcomes.

We therefore conducted analyses to examine factors predicting respondents’ organisational safety culture scores. We found that the variable “Sometimes I feel pressured to continue working, even if it is not perfectly safe” was the only variable which contributed significantly. As noted above, we also found that this variable is influenced by organisational safety culture. Thus, it is difficult to assess the causal relationship between these variables. Our study has been unsatisfactory when it comes to identifying the variables influencing organisational safety culture.

However, it may well be that the organisational safety culture on board the vessels that we have studied follow from the framework conditions of the sector (e.g. market, economy, manning level, work load). Thus, perhaps organizational safety culture interventions would be insufficient? Our results indicate, however, that a good organisational safety involves less demanding working conditions. Thus, perhaps safety culture interventions may help crew members reduce the impact of high workloads, low manning and fatigue? Future research should examine these questions. Below, we suggest that studies of working conditions on vessels with low manning levels could help us answer these questions. It is important to note, however, that these merely are hypotheses for further research.

### **Working conditions on vessels with low manning**

Reference group members considered fatigue and manning level to be among the most important risk factors in maritime transport. They stated that the small NOR ships transporting goods along the coast of Norway have low manning, considerable work pressure and scarce time. This may lead to too high workloads and fatigue, they suggested. Increase in the administrative burden were also emphasized as factors that may lead to fatigue on board Norwegian vessels.

As noted above, data from the small-scale survey indicates that the vessels with low manning (3-4 people) score lower on many of our variables measuring occupational safety and organisational factors. Seafarers on vessels with a manning of 3-4 people rate the safety level of their work place as lower than other respondents. They also rate their organisational safety culture as lower, they report of more pressure to work even though it is not perfectly safe, they agreed less that they get sufficient sleep and rest on board, they experience more often demanding working conditions, and they report of higher levels of safety-compromising fatigue.

These results could perhaps be interpreted as data supporting the hypothesis coined by our interviewees and references group members; suggesting that the small NOR ships transporting goods along the coast of Norway have low manning, considerable work pressure and scarce time, resulting in negative safety outcomes. It is important to note that we do not examine whether manning levels are too low on these vessels, we merely compare occupational safety and organisational factors.

Why and how do manning levels matter for occupational safety? Why do vessels with low manning score lower on safety outcomes and variables measuring organisational factors. The qualitative data indicates, as mentioned, that economic framework conditions are an important explanation. But is this because more work pressure is caused by challenging economic framework conditions? Moreover, to what extent is it possible to reduce the impact of challenging framework conditions by means of safety culture interventions?

Additionally, we may ask whether the vessels with lower manning have fewer resources available for managing safety than larger vessels? Finally; perhaps implementing formal safety management systems is seen as less important on small crew vessels, as crew size allows for coordination and management to take place through direct informal contact? Our results indicate that the higher manning level the vessels have, the more respondents agree that they have job descriptions/ procedures that describe the hazards of various work assignments. These questions should be examined in future research.



## **How important are safety management systems for occupational safety?**

According to the 2010 amendments to the ISM code, shipping companies and masters have a considerable responsibility when it comes to maintaining an updated and comprehensive Safety management system (SMS), focusing on proactive and regularly updated risk assessments, procedures and corrective actions. The Accident Investigation Board for maritime transport in Norway (AIBN) points to three key elements in safety management systems: 1) risk analyses, 2) procedures and 3) training. Respondents were therefore asked about these factors.

We conducted analyses to examine factors predicting respondents' answer to the question on procedures describing hazards, and found that the most important predictor of respondents' answers to the question was organisational safety culture.

Additionally, we made an index of three statements about procedure violations and lacking use of procedures. Again, we found that organisational safety culture was the most important predictor. A good safety culture reduces the occurrence of procedure violations and lacking use of procedures. These results indicates a relationship between safety culture and safety structure; between formal and informal aspects of maritime safety.

Nævestad et al (2015) study all reports from the AIBN between 2009 and 2014, and find that lack of complete, written risk assessments was the most frequently occurring risk factor in the AIBN reports. Although accident investigations often conclude that proper risk assessments would have identified the relevant risks, it is not given that vessels which have not been involved in accidents on average have better SMS than those which have had accidents. More research is needed to examine the importance of SMS for safety.