# ASSESSING THE DETERMINANTS OF SAFETY CULTURE IN THE MARITIME INDUSTRY

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**SUMMARY**

This paper presents the study approach, findings and the way forward of an Australian Linkage Council funded collaborative research project. The research was conducted by a group of researchers from the Australian Maritime Safety Authority, Curtin University and the University of Queensland, focusing on safety culture. More than 1,000 seafarers from 197 ships comprising 23 flag States were surveyed. The survey assessed safety culture, work demands, fatigue, mental health, and well-being and safety performance. Results show that although safety culture was viewed positively, a number of risk factors were also reported that could have a negative influence on safety. For example, the data indicates that work demands are high and negatively impact seafarers' recovery and long term wellbeing. Similarly, the negative types of safety compliance behaviours reported by participants are an indicator of reduced levels of safety culture. The findings are being used to implement a set of recommendations to improve safety on board ships. The recommendations center on a) improving the quality of work procedures; b) introduction of effective fatigue management systems; and c) improving the quality of work design and organisational support. The findings of this study have been presented at a range of industry forums, briefings, and at the International Maritime Organization.

**NOMENCLATURE**

IMO International Maritime Organisation
DSCS Developmental Safety Culture Survey

## 1. INTRODUCTION

### 1.1 SAFETY CLIMATE, SAFETY CULTURE, BEHAVIOUR AND OUTCOMES

The term "safety culture" refers to the way that an organisation manages safety, and reflects the core beliefs and attitudes that guide behaviour and decision-making (Casey, Griffin, Flatau Harrison & Neal, 2017). There are two broad elements of safety culture. The first are the policies, practices and procedures that the organisation has for managing safety. This first element is sometimes referred to as "safety climate" within the academic literature (Griffin & Neal, 2000; Neal, Griffin, & Hart, 2000). The second are the values, priorities, norms and motives held by people in the organisation. These two elements reflect the distinction between safety climate as something that an organisation *has* (i.e., policies, practices & procedures) and safety culture as something that an organisation *is* (i.e., people with a shared set of values and beliefs). Measures of safety climate and culture are highly correlated, and are not distinguishable for practical purposes (Casey, et al., 2017). In this report, we use the term "safety culture" rather than "safety climate", because it is a broader term, and is more widely recognized within the maritime industry.

In a recent review, Lützhöft, Grech & Porathe (2011) and others (i.e. Grech, Horberry & Koester, 2008) identified safety culture as a critical risk factor for the maritime industry. They argued that whilst most accidents at sea are caused by human error, these errors are attributable to conditions created by the organisation. Specifically, safety-related policies and practices relating to communication, commitment, trust, incident reporting, risk management and training play an important role in shaping behaviour, which can either directly or indirectly affect safety. According to Lützhöft et al. (2011) maritime safety culture is a concern, because shipping operators are under significant cost pressures. While there is anecdotal evidence suggesting that maritime safety culture is a critical risk factor, research on maritime safety culture is limited and fragmented. Recent work indicates that the relationship that exists between safety culture, safety behaviour and safety outcomes observed in other high-risk industries may also exist within the maritime industry. While this evidence is encouraging more is needed to clarify the role of safety culture in the maritime industry, particularly in relation to seafarers aboard vessels operating in Australian waters. The remoteness of the work environment also creates other concerns with crew having limited social contact and may be isolated for long periods of time with little support, all of which can reduce performance, health and well-being (Oliver, Cheyne, Tomas, & Cox, 2002). Hence this study also included an evaluation of seafarer mental health and wellbeing in the context of safety culture.

The aim of the study was to identify the factors that have the strongest impact on safety on board international vessels operating in Australian waters, in order to provide recommendations on how to improve safety in the maritime industry. This paper presents a selection of the findings with a full report available upon request.

 

## 2. RESEARCH METHOD

### 2.1 MEASURES

For the purpose of this study the *Developmental Safety Culture Survey* (DSCS) developed by the research team was used to measure different levels of safety culture development. The DSCS distinguishes between different levels of safety culture development based on existing theory (Lawrie, Parker, & Hudson, 2006, Reason, 1997) and was validated during a pilot study.

The DSCS is a behaviourally anchored scale with nine items developed to tap into the "Systems and Processes" and "People" aspects of safety culture. An overview of the measurement model is presented in Figure 1. These elements reflect the working definition of safety culture provide by Hale (2000) with the measuring framework based on a modified version of a framework developed by Griffin and Neal (2000).

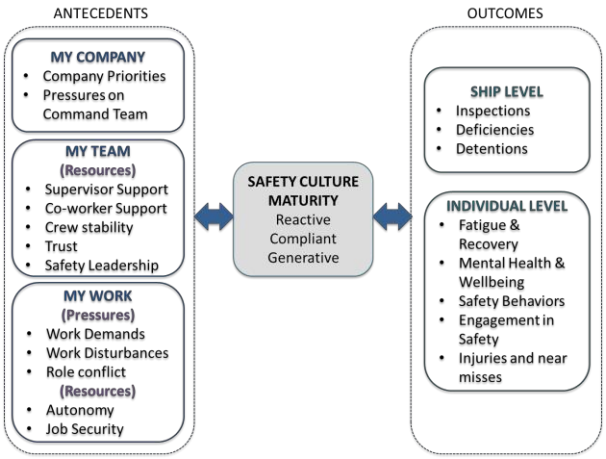


Figure 1: Overview of the overall measurement approach and variables included in this study.

The aspects measured in the "Systems and Processes" section included:

- Safety policies and procedures,
- Safety training,
- Communication,
- Role definitions,
- Reporting systems, and
- Operational schedules.

The "People" aspects included:

- Safety Values,
- Norms, and
- Motives.

The dynamism of safety culture was conceptualised through the typology of organisational culture (Westrum, 1993; Hudson, 2001). Based on this maturity model three specific descriptors were developed to reflect:

1. Pathological: dysfunctional/reactive safety culture;
2. Calculative: compliance oriented culture, and
3. Generative: participative/generative safety culture.

Participants responded on a 5-point Likert scale, where 1 received descriptors that reflected a reactive safety culture (pathological) and 5 represented descriptors that reflected a participative/generative safety culture. Participants indicated the value that best reflects the way each aspect was being managed on their ship.

As an example, when focusing on training participants were asked to describe '*How is training managed on this ship?*'. As indicated, three anchors were provided to help guide their responses. The pathological level anchor stated '*Crew is not trained to use the correct procedures and operate equipment safely'*. The calculative level anchor stated *'Crew is given the minimum training that is needed to ensure they are certified to do our jobs and comply with international requirements'*. The generative level anchor stated '*Training is comprehensive and covers both technical and non-technical aspects of safety (e.g. recognise unsafe situations, communicate with co-workers and work as a team)'*.

Similarly, when focusing on workplace norms participants were asked to describe '*What are the norms on this ship?'*. The pathological level anchor stated '*Most people in the ship think it's acceptable to break safety rules and procedures'*. The calculative level anchor stated '*Most people on the ship accept that it is necessary to follow the safety rules and procedures'*. The generative level anchor stated '*Most people on the ship expect everyone to do more than just follow the rules: everyone needs to show initiative and help improve safety'*.

As highlighted in Figure 1, several possible antecedents of safety culture were measured, situated at different levels: perceptions about my company, perceptions about my team, and perceptions about my work.

Outcomes were measures at the individual level (fatigue & recovery; mental health and wellbeing; safety behaviours; engagement in safety; injuries and near misses) and ship level which included self-reported safety outcomes and deficiency and detention data.

The survey also included a series of individual and work demographic questions. Examples of individual level factors included fatigue and recovery with participant's quality of sleep also assessed by asking whether they experienced sleep problems onboard the ship.

Beyond the general measures of compliance, the quality of safety behaviours were analysed by looking at two types of positive compliance behaviours: *adaptive compliance* and *deep compliance*; and two types of negative safety behaviours: *surface compliance* and *non-compliance*.

### 2.2 PROCEDURE

Participation in the study was voluntary and anonymity was guaranteed. The option of electronic and paper based surveys was provided. Partnerships with various organisations with direct contact to ships and seafarers were developed to increase survey reach. These included training providers, AMSA inspectors, pilots and seafarer welfare centres.

### 2.3 PARTICIPANTS

The final sample consisted of 1026 seafarers. 164 participants completed the command team survey and 862 participants filled in the survey for the rest of the crew. The difference in surveys were related to *work pressure*, *safety behaviours* and *safety engagement* questions. For the Command Team, the *work pressure* measures were supplemented with an extra measure of *role conflict* arising from their critical position as mediators between company and crew. The safety behaviours and safety engagement measures had different referents in which the Command Team were asked to provide an overall assessment of their crew behaviours using the same items, while the crew were required to only report on their own work behaviours and safety engagement.

97.9% of the participants were male with an average age of 34.7 years (*SD*=10.4 years). The age range for the majority of participants (57.8%) was between 18 to 37 years. Participants were mostly experienced seafarers, with an average overall tenure at sea of around 10 years (*M*=9.76, *SD*=8.78 years at sea). Most participants worked long contracts – in the region of 9 months to 1 year, especially evident for the officers and ratings. Most participants reported 4 months or less onboard the ship, with very few having been onboard for more than 9 months. The sample was represented by 40 nationalities with most of the participants coming from the Philippines. Participants were also asked to report how many different nationalities were on board their ship. On average, participants indicated that there were about 4 different nationalities on board the ship they were working on.

### 2.4 SHIP LEVEL DATA

All responses from seafarers on the same ship, identified by its IMO number, were averaged to obtain an overall score for the ship. 195 distinct ships were identified across the sample. The ships were then categorised into the following ship types: container (N=72), bulk carrier (N=33), general cargo (N=33), tanker (N=26), specialised (N=19), coaster (N=6) and passenger (N=6).

The breakdown of Flag States represented in this study was fairly consistent with the flag state population of vessels coming into Australian ports during the same year this survey was conducted. Panama (*N*=30) was the most frequently represented, followed by Singapore (*N*=27), Hong Kong (*N*=22), Liberia (*N*=20), Malta (*N*=13), Marshall Islands (*N*=12), Australia (*N*=11) and Bahamas (*N*=10).

## 3. DATA ANALYSIS AND REPORTING

Using SPSS statistical analyses tool the data were analysed at two distinct levels. First, an analysis was carried out at the individual level, taking into consideration the main differences and associations between responses offered by individual seafarers. The, data were analysed at the ship level by aggregating all individual responses from the same ship. Cross-level interactions using predictive models were also investigated in order to identify the effects of broader (ship level) factors on individual outcomes. The results highlight the strengths and weaknesses of safety culture, as well as its possible antecedents and consequences within the sample.

Due to increased pressures and uncertainty in the industry and the possible increased relevance of priorities communicated by companies, a multi-level analysis was also performed to investigate more closely the way perceptions of company priorities and operational uncertainty at the command team level might explain safety and well-being outcomes for the rest of the crew onboard the ship. The main interest was on the interplay between priority on safety and costs, but operational uncertainty was also added to the model. An overview of the predictors used in this analysis is presented in Figure 2. At the ship level of the multi-level model, priorities and operational uncertainty were included as perceived by members of the command team. The reasoning was twofold. First, company priorities are usually communicated to seafarers by the command team onboard the ship which inform their decisions and management on the crew. Second, from a methodological perspective, using two different sources for the different data: the command team for priorities and operational uncertainty, and the rest of the crew for wellbeing and safety outcomes ensures more robust results.

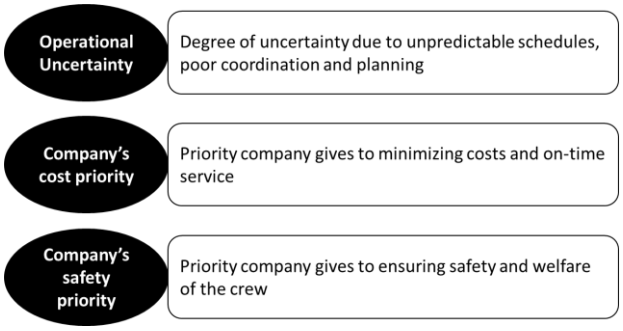


Figure 2: Overview of main predictors used in the multi-level analysis on priorities, operational uncertainty and their effects on safety and wellbeing.

## 4. FINDINGS AND DISCUSSION

The findings presented below align with the overall measurement approach as presented in Figure 1.

### 4.1 SAFETY CULTURE AND ITS ANTECENDENTS

Figure 3 shows the results of how participants evaluated safety culture across ships.

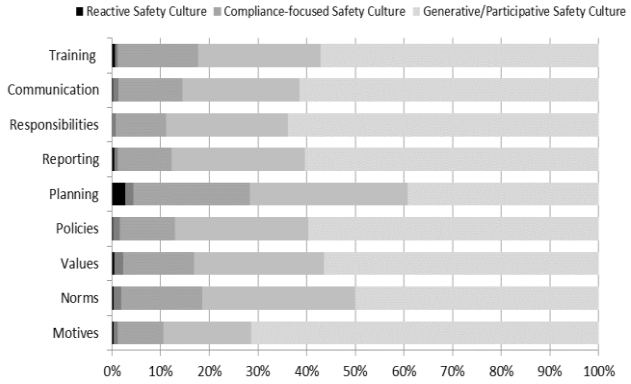


Figure 3: Breakdown of participants' responses on the SCDS dimensions.

Aspects that were most positively evaluated were those related to seafarers' perceived personal responsibility towards safety: *responsibilities and motives*. Although the overall findings show that safety culture was evaluated positively, there were still a number of cases for which safety culture was reported within the reactive–compliance based spectrum such as the *Planning and Scheduling* dimension. In addition, although formal mandatory requirements such as the International Safety Management Code are expected to have a positive impact on the evaluation of perception of systems and processes, it is also important to understand how these formal systems have an impact on safety behaviour and wellbeing of seafarers.

### 4.2 ANTECENDENTS – COMPANY PRIORITIES

Figure 4 presents an overview of how company priorities are perceived. Overall, seafarers perceive that companies place a great importance on preventing damage to the ship and cargo, as well as on the safety of the crew. However, about 20% of seafarers perceive that the company they work for places little or moderate importance on their welfare.

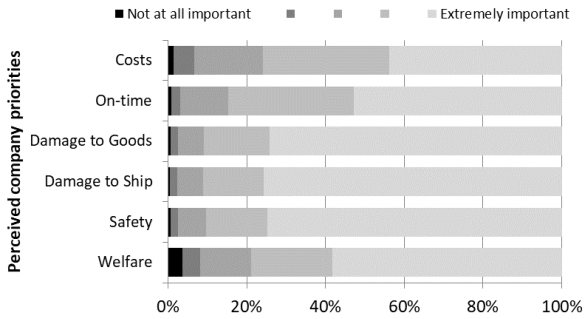


Figure 4: Breakdown of participants' responses on perceived company priorities items.

### 4.3 ANTECENDENTS - WORK DEMANDS

Participants reported working an average of 61.28 hours per week, with a standard deviation of 13.06 hours. The results indicate that a high proportion (almost 30%) of the participants are working long hours, exceeding 69 hours/week. Long working hours appear to be also coupled with increased work pressures and demands. More than 20% of participants reported that their working hours are unpredictable. Similarly, approximately 40% of participants reported working under time pressure, and about half of them reported experiencing high demands for vigilance at least sometimes in their work.

### 4.4 ANTECENDENTS - WORK DIFFICULTIES

Descriptive data on the three types of shipboard conditions (*work difficulties*) that might affect safety culture and safety outcomes: *physical conditions*, *technology and resources*, and *operational uncertainty* were analysed. Two categories of *physical conditions* were measured: external (weather, visibility and ship motion) and internal conditions (see Figure 6). Approximately 40% of participants reported that bad weather often caused difficulties in performing their work. Additionally, more than 20% of participants reported that poor visibility and ship motion often created difficulties for them in performing their work. Results for internal physical working conditions were similar (Figure 5), with loud noise and cramped workspaces being reported as a source of frequent disturbance by a high proportion of participants.

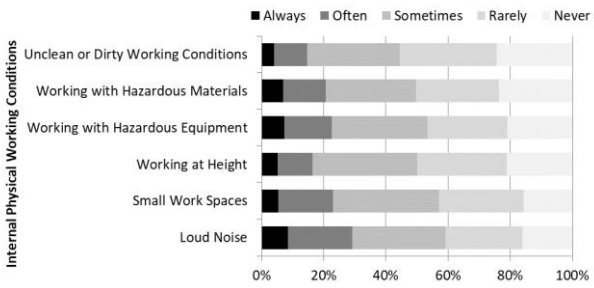


Figure 5: Breakdown of participants' responses evaluating how often internal physical conditions are creating difficulties for them in their work.

Scores for difficulties related to technology and resources were relatively homogenous. However, more participants (around 20%) reported that not having the needed supplies, and maintenance problems often created difficulties in performing work (Figure 6).


Figure 6: Breakdown of participants' responses evaluating how often conditions related to available technology and resources are creating difficulties for them in their work.

Approximately 40% of the sample reported difficulties related to operational uncertainty at least sometimes in their work. Scores are relatively homogenous across the factors measured, but frequent changes to schedule and manifest as well as disruptions or delays appear to be more common forms of difficulties (Figure 7).

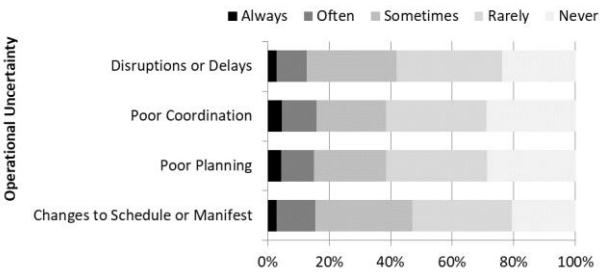


Figure 7: Breakdown of participants' responses evaluating how often conditions related to operational uncertainty are creating difficulties for them in their work.

## 4.5 ANTECENDENTS - SAFETY LEADERSHIP

Four different aspects of safety leadership were measured: *leverage*, *energise*, *adapt* and *defend*. Overall, all aspects of safety leadership received positive evaluations, with over 80% of participants agreeing that their supervisors exhibit all four of the surveyed safety leadership behaviours. It is indicated that the way leaders reflect and communicate safety goals, represents another type of work resource which plays an important role in health and safety outcomes.

## 4.6 OUTCOME – FATIGUE

Approximately 12% of the participants experienced sleep problems, while close to half of the participants reported no sleep-related difficulties. A similar pattern is observed in the participants' fatigue data. Approximately half of the participants reported experiencing low levels of fatigue, while close to 20% of the participants reported experiencing increased or high levels of fatigue, more notably, chronic fatigue.

## 4.7 OUTCOMES – MENTAL HEALTH AND WELLBEING

Mental health and wellbeing were measured as part of this study. Three aspects of wellbeing were measured: *hedonic*, *psychological* and *social* wellbeing. For mental health, almost 40% of the participating seafarers reported experiencing symptoms of mental ill health more frequently (eg. depression and anxiety). In terms of overall wellbeing, responses were more positive. However, the lowest percentages of wellbeing were found for social wellbeing. Not surprisingly, social wellbeing is the aspect of wellbeing that is more likely to be impacted by the working arrangements in the maritime industry which can be linked to social isolation which is supported by the literature (Iversen, 2012).

## 4.8 OUTCOMES – OVERALL SAFETY BEHAVIOURS

Overall *safety behaviours* were measured in terms of *safety task performance*, *safety participation* and *safety innovation*. High levels of these behaviours were reported, especially for safety task performance. The positive results for safety compliance do not necessarily reflect mature levels of participative/generative safety on board the participating ships. Participative/generative safety cultures are usually associated with less emphasis on overall compliance (safety task performance) and more safety participation and innovation. While safety participation and innovation levels were relatively high in this sample, levels of safety task performance reported were even higher indicating a strong emphasis on compliance.

## 4.9 OUTCOMES – TYPES OF SAFETY COMPLIANCE

Figure 8 presents the results for positive compliance behaviours.

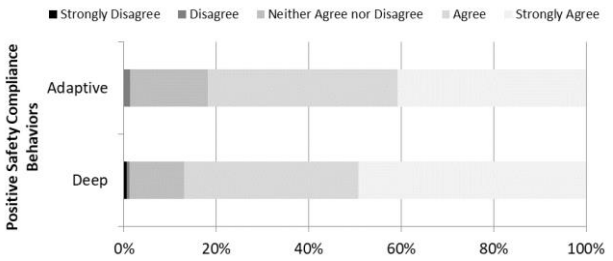


Figure 8: Breakdown of self-reported positive safety compliance behaviours.

The results suggest a high level of positive compliance. Most of the participants (approximately 80%) reported trying their best to apply the correct procedures to the task (deep compliance) and being adaptive, such as drawing on knowledge and experience to come up with a solution to complete the task safely when circumstances make existing procedures not appropriate (adaptive compliance).

However, when negative safety compliance behaviours are taken into account (Figure 9), the results indicate that non-compliance, and especially surface compliance, are also manifested by participants. Notably, more than 40% of participants reported that they sometimes just "tick the boxes" without paying too much attention to the actual procedures; and almost 20% reported some level of non-compliant behaviours (e.g. skip the procedures to get the work done). The results for positive and negative safety behaviours might appear contradictory at first glance. However, there are potential explanations for this pattern of findings. In particular, there are multiple procedures in place on any vessel, and seafarers might comply with some but not others. Even when overall compliance is positive, there might be situations of non-compliance or surface compliance that have the potential to put safety at risk.

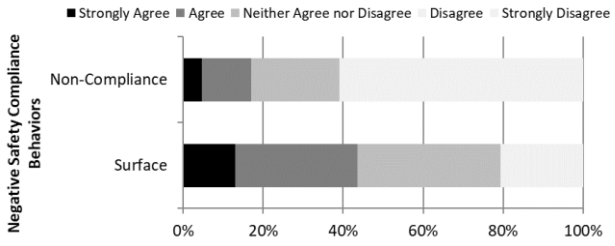


Figure 9: Breakdown of self-reported negative safety compliance behaviours.

## 4.10 MULTI-LEVEL ANALYSIS

### 4.10 (a) Perceived operational uncertainty, company priorities, and safety in relation to wellbeing and safety compliance outcomes.

The results (Figure 10) indicate that a priority on safety perceived at the command team level is not related to either wellbeing or safety compliance at the crew level. However, operational uncertainty and especially a company's priority on costs translate into negative outcomes for seafarers' wellbeing and safety compliance. These results converge toward the conclusion that prioritising costs and increased operational uncertainty might damage both safety and wellbeing, and a sole focus on safety would not be sufficient to counteract these effects.

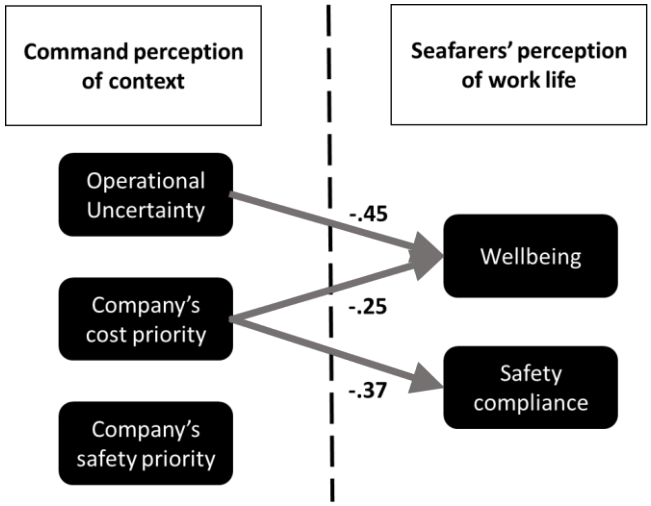


Figure 10: Overview of the multi-level analysis of the effects of perceptions of the overall context at the command team level on safety and wellbeing outcomes for the rest of the crew.

## 4.11 PREDICTIVE MODELS – SAFETY CULTURE

This more detailed analysis helped identify the strongest drivers for specific outcomes. Figure 11, shows that, in combination, an organisation's priorities, work pressures and work resources predicted 41.1% of the variance in safety culture's development level.

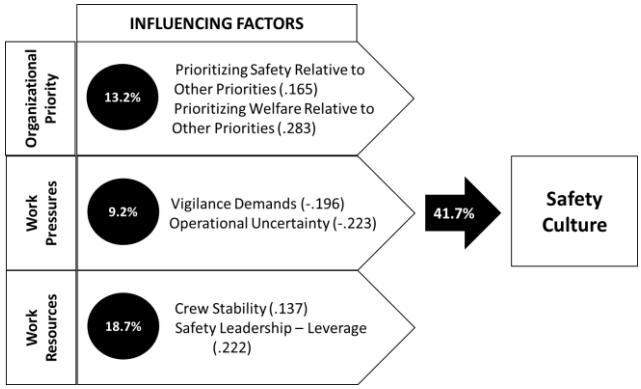


Figure 11: Overview of hierarchical regression analysis results that identify main drivers of safety culture levels on board participating ships.

Elaborating on earlier results, these findings indicate that when organisations prioritise safety and welfare over operational cost, operation schedule, and damage to goods and ship, safety culture is likely to be more mature. Additionally, when supervisors reward safety behaviours (leverage) and when crew stability is high, the safety culture is more likely to be a mature/generative one. In contrast, work conditions that leave seafarers struggling to concentrate and stay vigilant during work hours, or constantly having to deal with changes to schedules and manifest, poor planning, and disruptions to operations, are likely to lead to a less mature safety culture.

It is noteworthy that safety culture development level is best explained by work resources such as crew stability and behaviours of direct supervisors: – the more stable are the teams, and the more supervisors recognise and reward safety on board the ship, the better the safety culture. Therefore, interventions that improve crew stability and safety leadership of supervisors are likely to deliver positive outcomes for safety culture on board ships.

## 5. CONCLUSIONS

Approximately 40% of this study's sample indicated that they experienced difficulties in performing their tasks due to factors related to technology and resources, such as "poorly designed procedures/checklists" and "not having the right information". Similarly, conversations between seafarers and researchers during data collection revealed that a frequent complaint by seafarers was that there were too many procedures and many were too complicated for effective use. To encourage positive safety behaviours (e.g. deep compliance to safety rules and procedures), seafarers must have the necessary safety knowledge and motivation to perform their task safely, and this is determined, partly, by the degree of clarity and quality of the work procedures.

More than 20% of participants reported working more than 69 hours per week and that working hours were unpredictable. Approximately 12% of the participants reported experiencing sleep problems and 20% agreed that they experience some level of chronic and similarly 20% indicated experiencing acute fatigue. Further analyses revealed that chronic fatigue leads to reduced levels of psychological wellbeing that may impact on the overall functioning of employees.

## 6. RECOMMENDATIONS

A number of recommendations were developed based on information gathered from this study. The purpose is to propose research-based practices designed to manage the implications associated with this study's findings. This report focuses on two of these recommendations.

### 6.1 WORK AND PROCEDURES

The important role of the quality of work procedures in predicting compliance is evidenced in studies that show that procedures that were perceived as vague, inappropriate, poorly written or difficult to access were more likely to result in poor compliance (Dahl, Fenstad & Kongsvik, 2014). Hence, a focus on developing and ensuring high-quality work rules and procedures that are easily understood and are perceived as valid by those to whom they are addressed is critical.

### 6.2 FATIGUE MANAGEMENT

Organisations need to develop fatigue management interventions that continuously monitor and manage fatigue risks to prevent fatigue-related incidents or impaired psychological wellbeing. Managing the risk of fatigue requires a combination of intervention strategies with some being more effective than others. This is an approach successfully adopted widely in other transport modes (e.g. Gander, et al, 2011). The International Maritime Organization's (IMO) Maritime Safety Committee approved the revised *Guidelines on Fatigue* (MSC 1598) at its 100th session. Led by Australia, the revision resulted in a more useable guidance document. Central to these guidelines is the concept of a risk-based approach to fatigue management. This includes the approach that since fatigue affects the safe operation of the vessel, fatigue management should logically be an integral part of safety management systems. The Australian Maritime Safety Authority has developed useable guidelines to support fatigue risk management implementation in the maritime domain based on these guidelines.

## 7. ACKNOWLEDGEMENTS

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