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Original Article

Sleep and Fatigue Among Seafarers: The Role of Environmental Stressors, Duration at Sea and Psychological Capital

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A R T I C L E I N F O

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A B S T R A C T

Background: Seafaring is an inherently stressful environment. Because working time and leisure time is spent in the same confined environment for a prolonged period of time, many stressors present in seafaring can also be conceived of as chronic. We explored the effects of duration at sea, seafaring experience, environmental stressors, and psychological capital (PsyCap) on the sleep quality and fatigue of seafarers. PsyCap is a construct that draws upon ideas from positive psychology and positive organizational behavior, and is intended to capture an individual's psychological capacities that can be developed and utilized for performance improvements.

Methods: We collected survey data from a sample of seafarers working in the offshore re-supply industry ($n = 402$) and a sample of seafarers working on board combined passenger and cargo ships ($n = 340$).

Results: PsyCap emerged as a robust predictor with statistically significant relations to fatigue and sleep quality in both samples. PsyCap also interacted with duration at sea in explaining fatigue in seafarers working on board the passenger and cargo ships. Seafarers on passenger and cargo ships also reported significantly higher levels of fatigue than those working in the offshore re-supply industry.

Conclusion: Coupled with emerging research showing that PsyCap is trainable, our results suggest that maritime organizations could have much to gain by being cognizant of and developing routines for continually developing the PsyCap of their employees.

1. Introduction

Working in an isolated and confined environment (ICE) can be challenging for the psychological functioning of employees [1,2]. In a review paper focusing on polar expedition teams and space crews (both actual and simulated), Sandal et al [2] outlined some of the challenges, such as simultaneously living and working in the same confined environment, restricted social contact and isolation from family and friends, and the inability to leave the work-place for prolonged periods. Seafaring, while obviously not as extreme as polar or space expeditions, can also be construed as an ICE. In fact, many of the challenges outlined by Sandal et al very much apply to the life of seafarers as well, who work and live in the confined space of the vessel and who spend their free time in the same environment as they do when working.

Stressors facing seafarers are receiving increased attention [3,4]. In addition to those mentioned above, several important aspects of seafaring have been highlighted. For example, noise within the vessel, vibration caused by the engine and motion caused by harsh weather are all known to be significant stressors [5]. The motion of the vessel can lead to a disorder known as the sopite syndrome: a symptom complex that includes, among other things, drowsiness, lethargy, apathy, disinterest and disinclination to work, lack of participation in group activities, sleep disturbances, and mild depression [6].

A more general state of mental or physical fatigue is also a known risk factor of working at sea [4,5]. In one recent study of seafarers working on board supply vessels serving the oil and gas exploration industry on the Norwegian continental shelf, Hystad et al [7] found that both excessive work demands and perceptions of safety climate influenced the reported fatigue of the seafarers. Moreover, seafaring is still very much a 24-hour society. Personnel on commercial vessels perform a large variety of duties around-the-clock, such as maintenance, navigation, and cargo handling, activities that often take place under time-pressure and hectic activity. Watch-keeping and critical operational activities that

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frequently take place during the night require long and irregular work hours. As a result, the circadian rhythm and normal sleep patterns of the seafarers can be disturbed [8], which in turn can lead to poor sleep quality and fatigue.

Because seafarers live and work in the same quarters for a prolonged period of time, many stressors present in seafaring can be conceived of as chronic stressors. According to Doyle et al [9], chronic work stressors can be defined as "long-lasting events or characteristics of the environment, which place individuals at risk of experiencing stress and reduce well-being" (Introduction, paragraph 2). As it has also been suggested that such a prolonged exposure to the seafaring environment will lead to greater stress [10,11], one aim of this study was therefore to explore how duration of work period at sea influences the fatigue and sleep quality of seafarers. More specifically, we investigated whether longer durations at sea are associated with more reported fatigue and poorer sleep quality.

Of course, not everyone responds similarly to challenging circumstances. Several notable researchers have argued that stress is a transactional phenomenon between the individual and the environment that is largely dependent on the meaning given to the stimulus by the perceiver [12,13]. Lazarus' influential transactional model, for instance, states that potential stressful events are met first by primary appraisals and then by secondary appraisals. A primary appraisal is an individual's judgment about the significance of an event as threatening or positive, and as relevant or irrelevant to their situation. The subsequent secondary appraisal is an assessment of the available coping resources and options, that is, what can be done about the situation [13].

Since seafaring can be considered an inherently stressful environment, it is important to identify characteristics of individuals who are not as susceptible to the ill effects of stressful circumstances. Such an approach can be termed *salutogenic* in the language of Antonovsky [12]—as opposed to the traditional pathogenic approach taken by much psychological research—and has seen an increase with the popularity of the positive psychology movement [14].

Psychological capital (PsyCap) is an individual characteristic that has received considerable attention in positive psychology research, particularly within the emerging sub-field of positive organizational behavior [15]. PsyCap is usually considered as a higher-order personality construct comprising four different elements: self-efficacy, optimism, hope, and resiliency. Within this framework, the person high in PsyCap is characterized as: (1) having the confidence (self-efficacy) to take on and put in the necessary effort to succeed at challenging tasks; (2) making positive attributions (optimism) about succeeding now and in the future; (3) persevering toward goals and, when necessary, redirecting paths to goals (hope) in order to succeed; and (4) when beset by problems and adversity, sustaining and bouncing back and even beyond original states (resiliency) to attain success [16].

Previous research has shown that the individual characteristics associated with PsyCap enhance coping and health. In a meta-analysis of then available research, Avey et al [17] revealed positive associations between PsyCap and employee psychological well-being, as well as negative associations between PsyCap and job stress and anxiety.

Another individual difference variable relevant in the current context is seafaring experience. It is plausible that previous experience with working in ICEs could familiarize individuals with what to expect in terms of stressors in the environment, and in extension equip them with adequate coping strategies [9]. One could therefore conceive of seafarers with greater experience developing strategies for dealing with stress over long voyages. Since experience and responsibility tend to coincide with age, a contrasting theory could be that work-related stress increases with experience and responsibility, because work-related stress tends to increase with age. Griffiths et al [18], for instance, reviewed several large scale studies related to age and stress, and concluded that work-related stress increases with age, peaking at about 50–55 years.

As already mentioned, one aim was to investigate the relation between duration at sea and fatigue and sleep quality. In addition, we wanted to explore some additional potential predictors of sleep quality and fatigue. Specifically, we investigated the influence of PsyCap, seafaring experience and some known predictors of sleep quality and fatigue such as noise, vibration and vessel motion. Because PsyCap is considered as a metaconstruct that encompasses several individual characteristics that has been known to foster psychological resiliency (i.e., self-efficacy, optimism, hope, and resiliency), it is reasonable to expect PsyCap to buffer any negative effects that duration at sea and other stressors present in the seafaring environment might have. Consequently, a final aim of this study was to explore the interactions between PsyCap and duration at sea and environmental stressors.

To achieve these aims, we sampled seafarers from two different maritime organizations. One sample consisted of seafarers working on supply vessels serving the offshore oil and gas industry. The other sample consisted of seafarers working on board combined cargo and passenger roll-on/roll-off (ro-ro)[1] ferries. In addition to providing two different maritime contexts in which to explore our aims, this design also allows for comparing the two maritime contexts in terms of fatigue.

2. Materials and methods

2.1. Participants and Procedure

2.1.1. Sample 1: Offshore supply

For the offshore oil and gas supply sample, 926 questionnaires were administered to seafarers working on board 22 different vessels operating in the North Sea and south-eastern Asia. The questionnaires were sent from the shipping company's onshore shipping and forwarding agent and returned in anonymous, sealed envelopes to the first author of this paper. A total of 402 questionnaires were returned, yielding a response rate of 43.4%.

The majority of respondents were Norwegian (n = 138; 34.3%) or Filipino (n = 146; 36.3%), with the rest of either other European (n = 98; 24.1%) or Asian/Australasian origin (n = 15; 3.6%). Age was recorded in categories, and 49 (12.2%) reported to be 24 years or younger, 68 (16.9%) were aged 25–29 years, 130 (32.3%) were aged 30–39 years, 111 (27.6%) were aged 40–54 years, and 39 (9.7%) were 55 years or older (5 respondents did not state their age). Due to the low number of women working on board the vessels, the sex of participants was not recorded in order to protect the anonymity of women seafarers. Norwegian crewmembers received surveys written in Norwegian, while the others were given their surveys in English. According to the shipping company in question, all crewmembers are required to be fluent in English as a condition of employment.

[1] Roll-on/roll-off (ro-ro) ships are vessels designed to carry wheeled cargo (e.g. automobiles) and have built-in ramps that allow cargo to be efficiently rolled on and off the vessel when in port. The term ro-ro is generally reserved for larger oceangoing vessel and does not typically include smaller ferries that operate across rivers and other short distances, but which also often have built-in ramps.

2.1.2. Sample 2: Ro-ro ferry

Respondents in Sample 2 were seafarers working on board 11 combined freight and passenger ro-ro ferries operating on the Norwegian coast. A total of 340 questionnaires were returned, and because we cannot be sure about exactly how many crewmembers received the questionnaire, an exact response rate is difficult to establish. Assuming a mean crew of 50 for each vessel, and two different crews for each vessel (i.e. a total sampling frame of 1,100), a very conservative estimation of the response rate yields 30.9%.

The majority of participants were Norwegian ($n = 311$; 91.5%), with the remainder hailing from other European countries ($n = 20$; 5.9%; 9 participants did not state nationality). All questionnaires were, however, administered in Norwegian because all crewmembers in the surveyed company were expected to be fluent in Norwegian. The mean age of the participants was 37.02 years [standard deviation (SD) = 13.29] and the majority were men ($n = 218$; 64.1%).

Respondents were given prepaid envelopes in which to return the questionnaires. Both data collections were also reviewed and approved by the Norwegian Social Science Data Service, the institution that serves as the University of Bergen's Privacy Ombudsman for Research. Participants gave their informed consent and were informed that they could withdraw from the study at any time.

2.2. Measures

2.2.1. PsyCap

The Psychological Capital Questionnaire (PCQ) [16] was used to measure PsyCap. The original PCQ consists of 24 statements that participants respond to using a six-point scale with anchors of 1 = Strongly disagree and 6 = Strongly agree. Six statements each are used to measure the four proposed PsyCap dimensions. In the present study, an abridged 12-item version of the PCQ was used. Example items are: When things are uncertain for me at work I usually expect the best (optimism), I can get through difficult times at work because I've experienced difficulty before (resiliency), At the present time, I am energetically pursuing my work goals (hope), and I feel confident presenting information to a group of colleagues (self-efficacy).

Total PsyCap scores were created by averaging the responses to all items. Cronbach α for the total PsyCap score was 0.90 and 0.81 in the supply vessel sample and the ro-ro sample, respectively.

2.2.2. Fatigue

The Swedish Occupational Fatigue Inventory [19,20] is a self-report instrument to measure work-related perceived fatigue across five dimensions: Lack of energy (e.g. worn out), physical exertion (e.g. out of breath), physical discomfort (e.g. stiff joints), lack of motivation (e.g. lack of concern), and sleepiness (e.g. *drowsy*). If one wishes, the physical exertion and discomfort dimensions can be combined into a physical component of fatigue, while sleepiness and lack of motivation can be combined into a mental component. Lack of energy has been suggested to represent a more general factor that reflects both the physical and mental aspects of fatigue [20].

In the present study, participants in both samples were asked to think about how they felt at the end of their shift, and then rate 20 Swedish Occupational Fatigue Inventory expressions on a seven-grade response scale with anchors of Not at all and to A very high degree. There are four expressions each for the five different fatigue dimensions. In the supply vessel sample, the Cronbach α values were 0.87 for physical fatigue, 0.90 for mental fatigue and 0.90 for lack of energy. In the ro-ro ferry sample, the corresponding α values were 0.88, 0.89 and 0.91 for physical fatigue, mental fatigue and lack of energy, respectively.

2.2.3. Sleep quality

In the ro-ro ferry sample, subjective sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI) [21]. Although the PSQI consists of self-rated questions along seven different components, only the sleep quality, sleep latency, and sleep duration components were recorded in the present study. Each component was scored according to the instruction from 0 to 3, and then summed into a global PSQI-score. The PSQI has previously been validated in Norwegian with satisfactory validity and reliability [22]. The Cronbach α in the present study was 0.56.

In the supply vessel sample, a single item was used to assess subjective sleep quality. Respondents were asked to rate their current sleep quality using a scale ranging from 1 = very poor to 5 = very good.

2.2.4. Environmental stressors

Participants in the ro-ro ferry sample were asked to judge to what degree they felt disturbed by five different environmental factors: noise (e.g., from engine room); motion of the ship; frequent port turnarounds; sleep quarters too bright; and sleep quarters too cold or hot. These features of the work environment were identified in a review of relevant literature as significant sleep disturbing/-impeding factors (e.g., 5). To compute an overall environmental stress score, responses to these five items were averaged (Cronbach $\alpha = 67$).

2.2.5. Duration at sea and seafaring experience

In addition to the scales summarized above, participants in both samples were asked how long they had been on board since their last shore leave at the time of survey completion. The seafarers working on board the ro-ro ferries generally work a shift pattern in which they sail for 22 days followed by 22 days leave onshore. Responses to the question on duration at sea were therefore recorded as an open-ended number of days. The seafarers working on the supply vessels generally have longer sailing periods, and responses to this question were therefore recorded in the following categories: < 1 week, 1–2 weeks, 3–4 weeks, 5–6 weeks, 7–8 weeks, 9–10 weeks, 11–12 weeks, and > 12 weeks.

Participants in both data collections were also asked an open-ended question about the length of their seafaring career.

2.2.6. Statistical analyses

In order to explore if duration at sea was related to fatigue and sleep, we started by plotting duration at sea against sleep and fatigue scores. All individual scores were aggregated, that is; the scores of all individuals reporting the same duration at sea were computed into a mean score.

Next, we performed a series of linear regressions regressing sleep and fatigue on our explanatory variables. Because the three fatigue dimensions were all highly intercorrelated in both samples (r values between 0.62 and 0.82), we decided to use an overall index of fatigue in the regression analyses. The observations in our study are nested in ship clusters, and we therefore used a generalization of the Huber/White/sandwich estimator that relaxes the assumptions of normality in the errors and that is also robust to heteroscedasticity [23,24]. This estimator relaxes the usual requirement that the observations be independent and replaces it with the assumption of independence between clusters. In other words, the observations are assumed to be independent across all ships included in our study but not necessarily within the ships.

To test whether PsyCap moderated the effects of duration at sea and environmental stressors, we introduced product terms (PsyCap $\times$ duration; PsyCap $\times$ stressors) into the regressions. Statistically significant interaction terms were followed up using the Johnson-Neyman (JN) technique [25]. In short, the JN technique identifies the *regions of significance*: the point or points along the continuum of the moderator where the conditional effect of the independent variable on the outcome moves from being statistically significant and not significant at the α level of significance.

Finally, we performed an independent samples *t* test to compare the level of fatigue between seafarers working in offshore supply and seafarers working in ro-ro passenger and cargo vessels.

3. Results

In the ro-ro sample, participants had been at sea for a mean duration of 12.1 days (SD = 6.2). In the supply sample, the modal group consisted of seafarers who had been at sea for 3–4 weeks (27.4%), followed by 1–2 weeks (22.9%), and < 1 week (15.2%).

Fig. 1 depicts the relationships between duration at sea and fatigue and sleep for the ro-ro ferry sample. As is evident from the figure, no discernible linear relations were evident between duration at sea with either subjective sleep quality or fatigue. This is further corroborated by the null correlations presented in Table 1.

Fig. 2 displays the corresponding relations for the supply vessel sample. Again, there did not seem to be much of a relation between duration at sea and sleep quality or fatigue. Table 2 nevertheless shows that there was indeed a small, but statistically significant, positive relation between duration at sea and fatigue (r = 0.10, p = 0.046).

We next performed a series of regression analyses regressing fatigue and sleep quality on our explanatory variables. In the ro-ro ferry sample, the explanatory variables were seafaring experience, duration at sea, environmental stressors and PsyCap. In addition, we included age and sex as control variables. Because of missing values on the explanatory and criterion variables, our sample size was reduced to $n = 290$ ($n = 291$ for the analysis involving sleep quality). The results from the series of regressions in the ro-ro ferry sample are presented in Tables 3 and 4.

As can be seen from Tables 3 and 4, environmental stress and PsyCap both significantly predicted fatigue and sleep quality. Seafarers reporting being disturbed by environmental factors also report poorer sleep quality (B = 0.26, 95% confidence interval: 0.15–0.37) and report being more fatigued (B = 0.53, 95% confidence interval: 0.24–0.82). PsyCap, by contrast, was negatively related to both criteria, with B = −0.46 (95% confidence interval: −0.92 to −0.01) for fatigue and B = −0.26 (95% confidence

Table 1
Means, standard deviations, and pairwise correlations between study variables in the ro-ro sample

Variables	1	2	3	4	5	6	7	8
1. Sex	–	–	–	–	–	–	–	–
2. Age	−0.01	–	–	–	–	–	–	–
3. Experience	−0.26†	0.76†	–	–	–	–	–	–
4. PsyCap	−0.08	0.05	0.02	–	–	–	–	–
5. Time at sea	−0.07	0.06	0.02	0.02	–	–	–	–
6. Fatigue	0.15*	0.01	−0.04	−0.30†	−0.05	–	–	–
7. SQ	0.06	−0.01	−0.01	−0.27†	−0.03	0.40†	–	–
8. ES	−0.04	−0.02	−0.03	−0.21†	−0.04	0.38†	0.34†	–
Mean	64.1‡	37.02	11.87	4.80	12.13	2.86	1.32	1.93
SD	–	13.29	11.19	0.53	6.21	1.20	0.66	0.81

ES, environmental stressors; PsyCap, psychological capital; SQ, sleep quality.
* $p < 0.05$.
† $p < 0.01$.
‡ Denotes percentage men.

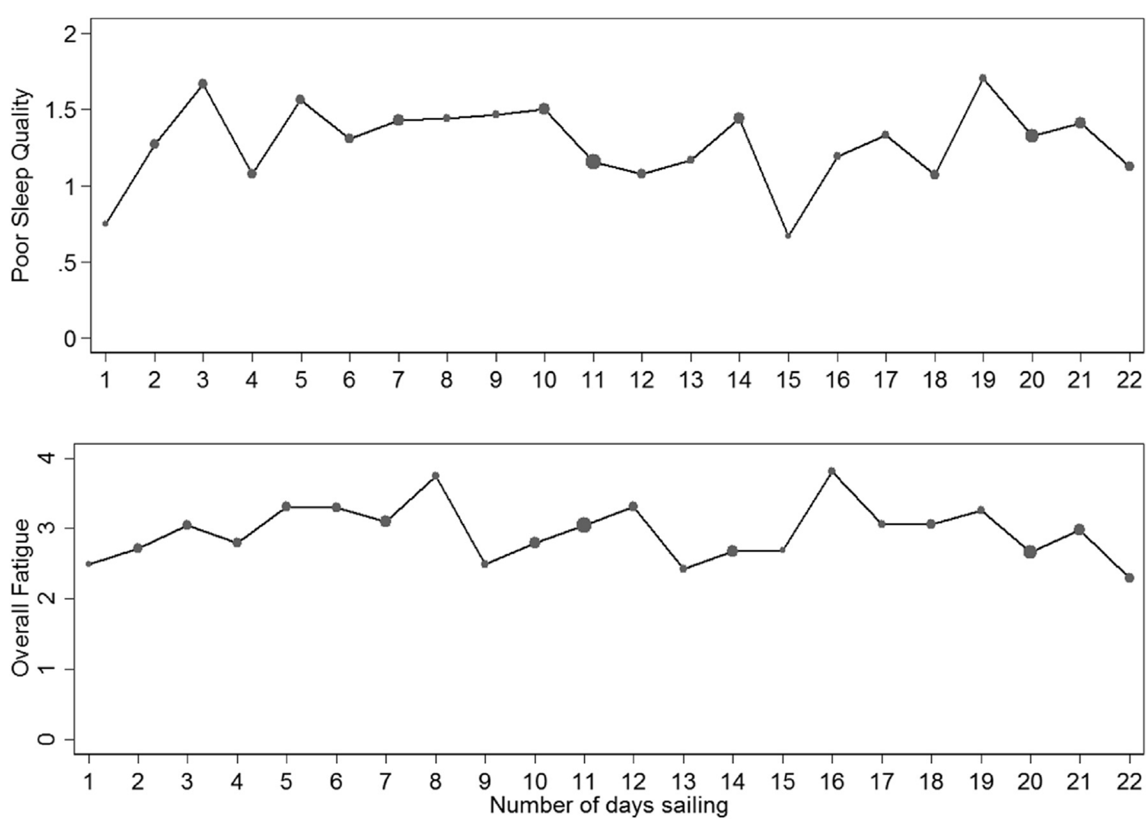

Fig. 1. The relation between number of days sailing and fatigue and sleep quality in seafarers working on board ro-ro passenger and cargo ships. Fatigue and sleep quality scores are aggregates of individual responses. The sizes of the markers in the scatter plot are weighted according to the number of individuals providing responses. Larger markers thus represent a larger number of responses.

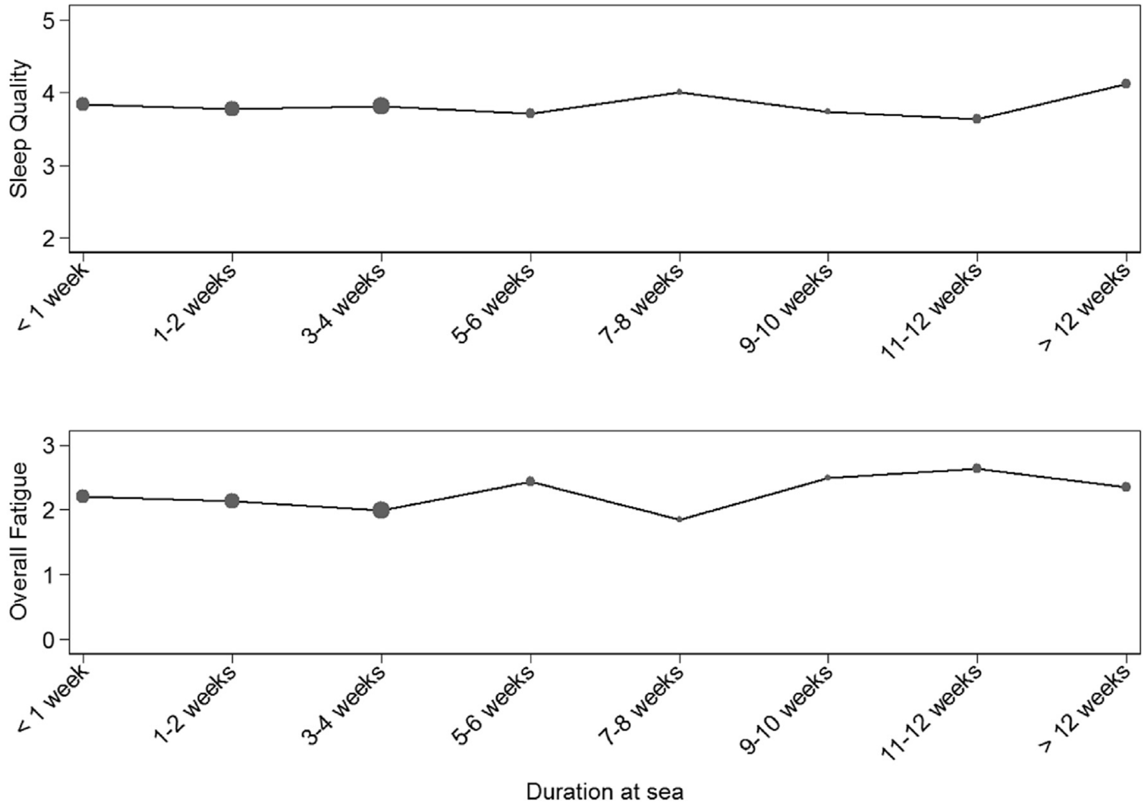

Fig. 2. The relation between duration at sea and fatigue and sleep quality in seafarers working on board offshore supply vessels. Fatigue and sleep quality scores are aggregates of individual responses. The sizes of the markers in the scatter plot are weighted according to the number of individuals providing responses. Larger markers thus represent a larger number of responses.

interval: −0.47 to −0.06) for poor sleep quality. Combined, our explanatory variables explained 22.3% of the variance in fatigue and 18.3% of the variance in sleep quality.

Entering the product terms in Step 2 of the regression analyses revealed a significant interaction between PsyCap and duration at sea for both fatigue and sleep quality, explaining an additional 2.3% and 1.1% of the variance in fatigue and poor sleep quality, respectively. To probe these significant interactions further, we computed the regions of significance using the JN technique. A plot visualizing the results for the conditional effects of duration at sea on fatigue is presented in Fig. 3. Duration at sea can be seen to have a positive relation with poor sleep quality at lower levels of the moderator PsyCap, and a negative relation at the extremes of the moderator PsyCap. The region of significance can be defined as the values of the moderator for which the confidence interval for the conditional effect does not contain the value zero. Fig. 3 thus shows that the conditional effect of duration at sea on fatigue is only statistically significant at very high levels of PsyCap, at values of 5.2 and above, to be precise.

The JN analysis for the conditional effect of duration at sea on sleep quality revealed no solution within the range of the moderator PsyCap. According to Hayes [26], the JN technique will sometimes produce results in which the region of significance is outside the range of the particular measurement scale or that is in the realm of imaginary numbers. In our case, the analysis showed that the conditional effect of duration at sea on sleep quality was not

Table 2
Means, SD, and pairwise correlations between study variables in the supply vessel sample

Variables	1	2	3	4	5	6
1. Age	–	–	–	–	–	–
2. Experience	0.72†	–	–	–	–	–
3. PsyCap	0.02	0.03	–	–	–	–
4. Duration at sea	−0.12*	−0.06	0.17†	–	–	–
5. Fatigue	−0.09	−0.13*	−0.17†	0.10*	–	–
6. SQ	−0.04	−0.03	0.25†	0.05	−0.30†	–
Mean	30–39 y‡	14.78	5.07	3–4 wk‡	2.19	3.8
SD	–	10.94	0.60	–	1.04	0.84

PsyCap, psychological capital; SD, standard deviation; SQ, sleep quality.
* $p < 0.05$.
† $p < 0.01$.
‡ These represents the most frequent age and duration at sea (modal) categories in the supply vessel sample.

Table 3
Summary of regression predicting fatigue in the ro-ro sample

Variable	Step 1		Step 2	
	B (SE§)	95% CI	B (SE§)	95% CI
Sex	0.38 (0.20)	−0.06; 0.83	0.39 (0.19)	−0.03; 0.82
Age	−0.01 (0.01)	−0.02; 0.01	−0.01 (0.01)	−0.02; 0.01
Experience	0.01 (0.01)	−0.01; 0.03	0.01 (0.01)	−0.01; 0.03
Duration at sea	−0.00 (0.01)	−0.03; 0.02	0.27* (0.12)	0.01; 0.53
ES	0.53† (0.13)	0.24; 0.82	0.27 (1.21)	−2.43; 2.98
PsyCap	−0.46* (0.21)	−0.92; −0.01	0.08 (0.56)	−1.17; 1.34
Duration × PsyCap	–	–	−0.06* (0.02)	−0.11; −0.01
ES × PsyCap	–	–	0.05 (0.26)	−0.54; 0.64
R^2	0.223‡		0.246‡	
ΔR^2	–		0.023‡	

Note. Sex is coded 0 = men; 1 = women. Table displays unstandardized regression coefficients.
CI, confidence interval; ES, environmental stressors; PsyCap, psychological capital.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.
§ Robust standard error.

Table 4
Summary of regression predicting sleep quality in the ro-ro sample

Variable	Step 1		Step 2	
	B (SE)	95% CI	B (SE)	95% CI
Sex	0.08 (0.07)	−0.07; 0.23	0.08 (0.07)	−0.09; 0.25
Age	−0.00 (0.00)	−0.01; 0.01	−0.00 (0.00)	−0.01; 0.01
Experience	0.00 (0.00)	−0.01; 0.01	0.00 (0.01)	−0.01; 0.01
Duration at sea	−0.00 (0.01)	−0.02; 0.01	0.11 (0.05)	−0.00; 0.21
ES	0.26† (0.05)	0.15; 0.37	0.16 (0.49)	−0.93; 1.26
PsyCap	−0.26* (0.09)	−0.47; −0.06	−0.05 (0.24)	−0.57; 0.48
Duration X PsyCap	–	–	−0.02* (0.01)	−0.04; −0.00
ES X PsyCap	–	–	0.02 (0.10)	−0.21; 0.25
R^2	0.183‡		0.194‡	
ΔR^2	–		0.011‡	

Note. Sex is coded 0 = men; 1 = women. Table displays unstandardized regression coefficients.
CI, confidence interval; ES, environmental stressors; PsyCap, psychological capital; SE, robust standard error.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.

significant anywhere in the observed distribution of PsyCap, and thus there was no region of significance.

In the supply vessel sample, the explanatory variables were seafaring experience, duration at sea, and PsyCap. Only age was included as a control variable as the sex of the participants was not recorded. Because of missing values on the explanatory and criterion variables our sample size was reduced to $n = 366$ ($n = 367$ for the analysis involving sleep quality). The results from the series of regressions are presented in Table 5.

PsyCap again showed statistically significant relations to both criterion variables. PsyCap was negatively related to fatigue (B = −0.38, 95% confidence interval: −0.59 to −0.17) and positively related to better sleep quality (B = 0.37, 95% confidence interval: 0.23–0.50). Duration at sea (B = 0.08, 95% confidence interval: 0.02–0.13) and seafaring experience (B = −0.01, 95% confidence interval: −0.02 to −0.001) also turned out to significantly predict fatigue, but not sleep quality. Longer periods at sea were thus related to more fatigue, while seafaring experience was related to less fatigue, although both effects should be considered as small. Fewer of the variations in the outcome variables were explained in this set of regressions compared with the analyses in the ro-ro sample; 7.5% for fatigue and 7.1% for sleep quality.

Table 5
Summary of regression predicting fatigue and sleep quality in the supply vessel sample

Variable	Fatigue		Sleep quality	
	B (SE)	95% CI	B (SE)	95% CI
Age	0.02 (0.06)	−0.11; 0.15	−0.00 (0.04)	−0.09; 0.09
Experience	−0.01* (0.01)	−0.02; −0.00	0.00 (0.01)	−0.02; 0.01
Time at sea	0.08† (0.03)	0.02; 0.13	−0.01 (0.03)	−0.07; 0.05
PsyCap	−0.38† (0.10)	−0.59; −0.17	0.37‡ (0.07)	0.23; 0.50
R^2	0.075‡		0.071‡	

CI, confidence interval; PsyCap, psychological capital; SE, robust standard error.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.

Adding the product term between duration at sea and PsyCap revealed no significant interaction in either the analysis with fatigue (B = 0.10, 95% confidence interval: −0.01 to 0.22) or sleep quality (B = −0.00, 95% confidence interval: −0.10 to 0.09).

3.1. Ro-ro versus supply sample

The results from an independent samples *t* test showed that workers on the ro-ro vessels (M = 2.86, SD = 1.20) reported

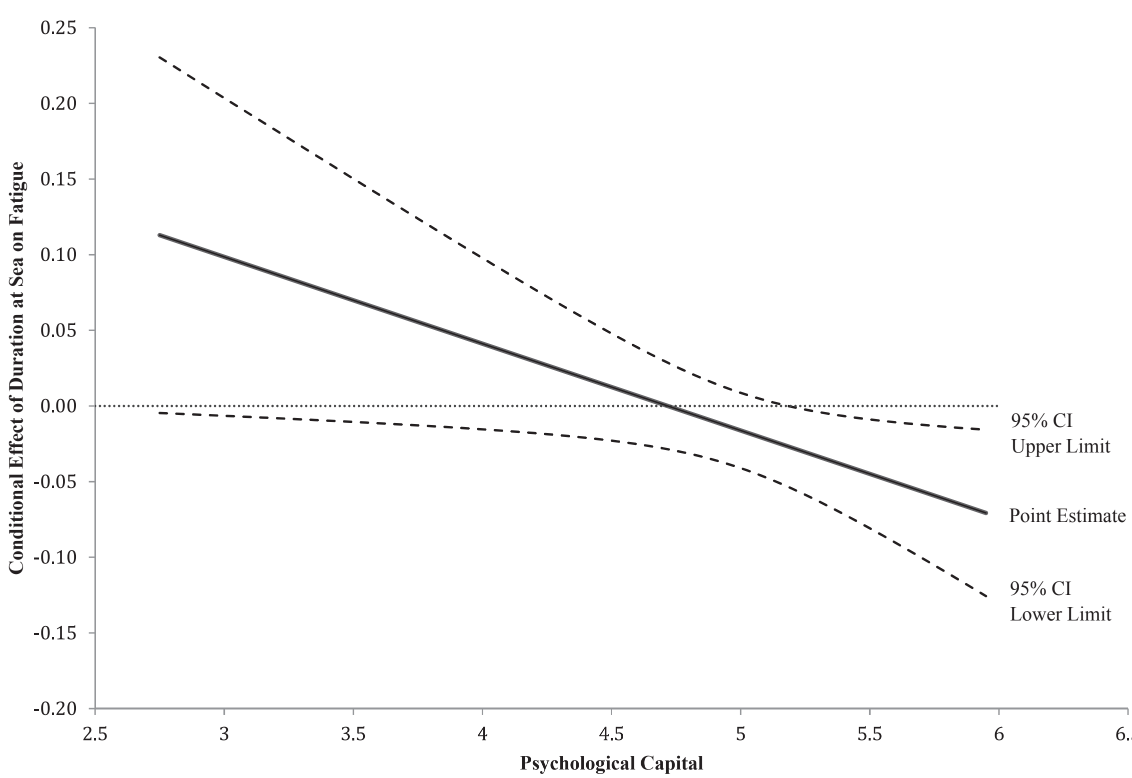

Fig. 3. Conditional effects with 95% confidence intervals of duration at sea on fatigue at different levels of psychological capital. Conditional effects with a confidence interval that include zero are not statistically significant different from zero.

statistically significant higher levels of fatigue than workers on the supply vessels [M = 2.19, SD = 1.0; t (638.513) = 7.842, $p < 0.001$, based on Satterthwaite's degrees of freedom for unequal sample variance]. Based on the usual recommendations regarding effect sizes [27], the difference in means in fatigue (Cohen D = 0.60) can be considered to be of medium magnitude.

4. Discussion

This study sought to investigate the impact of duration at sea on the sleep and fatigue of seafarers. Many stressors facing seafarers are chronic and prolonged exposure to the seafaring environment has been suggested to lead to greater stress [9,11]. A case can therefore be made for the seafarers' levels of fatigue to increase during their time at sea. The results from this study offer limited support for this notion. For seafarers on board the combined cargo and passenger ro-ro ship, the number of days sailing were unrelated to the reported levels of fatigue and sleep quality. These seafarers work a 22-day rotation pattern (22 days sailing followed by 22 days leave), and it is quite possible that such a relatively short duration at sea is not sufficient for the ship environment in and of itself to take its toll on the seafarers. Doyle and colleagues [9], for example, have suggested that the relationship between stress and duration at sea may only become evident on deployments longer than 6 months. For seafarers working on board supply vessels, by contrast, duration at sea was related to reported levels of fatigue. The regression analyses revealed a statistically significant, albeit small, positive relation between duration at sea and fatigue. Seafarers on board these vessels have longer deployments that are perhaps sufficient for the ship environment to exert an influence.

The results did reveal a significant interaction between PsyCap and duration at sea in predicting fatigue in the ro-ro sample. While the nature of this interaction resembled a typical buffering effect, inasmuch as duration at sea seemed to increase levels of fatigue at low but not at high levels of PsyCap, the follow-up analysis revealed that the conditional effects were only statistically significant at the very extreme end of the PsyCap distribution. Specifically, the interaction showed that longer durations at sea served to *decrease* levels of fatigue for seafarers very high in PsyCap, but had no effect at medium or lower levels of PsyCap. An interaction was also found in predicting sleep quality, but here the follow-up analysis revealed that the conditional effect of duration at sea was not significant anywhere in the observed distribution of PsyCap.

A possible explanation for the limited effect of duration at sea on fatigue and sleep quality in our sample can be found in the healthy worker effect (HWE). The term HWE was first coined by McMichael et al [28] to describe the long-known tendency of actively employed individuals to have lower morbidity and mortality than the population at large. Although our study can hardly be deemed an epidemiological study, one particular aspect of the HWE still seems relevant: the phenomenon often referred to as the healthy worker *survivor* effect [29,30]. Healthier workers are more likely to stay (i.e., *survive*) in the workforce compared with workers more responsive or sensitive to hazards, who in turn tend to transfer to jobs with less exposure or leave the workforce altogether. The main problem is that this really constitutes a selection bias to which cross-sectional studies are particularly susceptible. A disproportional number of workers who are resistant to the effects of the exposure(s) being studied are usually included, while short-term workers—those who transfer or leave the workforce—are consistently under-sampled. As a consequence, we run the risk of underestimating or masking the true adverse effect of an occupational hazard.

The results from the current study revealed that seafarers working on board ro-ro ships reported higher levels of fatigue compared with seafarers working on offshore supply vessels. To understand these results we must first look at some of the differences between these two maritime contexts. The ro-ro ships in question sail a continuous and fixed-pattern route up and down the Norwegian coast. The voyage from the southernmost to the northernmost port takes approximately 7 days, including numerous port calls every day where passengers and cargo are loaded on and off. Several of these port calls also take place during the night. Once the ships have reached their northernmost port they start the return voyage southwards, visiting the same ports as before. The offshore vessels in comparison do not have the same frequency of port turnarounds, but instead have longer voyages back and forth from their base to the offshore installations. These vessels can also have extended periods of inactivity either at port waiting for the next assignment or on the oil production sites when serving as *stand by* vessels. While both seafarers working on board ro-ro ships and supply vessels are expected to have long and demanding working days, it has nevertheless been suggested that the negative impact of long working days on fatigue is especially pronounced in combination with frequent port turnarounds [5,31]. Frequent port turnarounds could therefore present a possible explanation as to explaining why seafarers on board ro-ro ships report more fatigue.

By contrast, one could also argue that seafarers on board the ro-ro ship work in a less isolated and confined environment than the seafarers on board the supply vessels. The former have more space to move around (i.e., generally larger vessels), sporadic opportunities to leave the vessel during some of the frequent port calls, and at least some of the crew also have more frequent social interactions with passengers. Then again, the extra element of having passengers on board could also be a contributing factor towards higher fatigue. Perhaps providing passenger service in addition to the day-to-day operations of the vessel constitutes an extra stress-inducing factor that takes its toll on the crewmembers.

4.1. PsyCap, seafaring experience, and environmental stressors

Seafarers are continuously exposed to numerous ship-related stress factors both during their working time and during their leisure time. Environmental factors such as noise, ship motion and vibration are known to affect the wellbeing of seafarers, and indeed seemed to do so in our study. The regression analyses revealed that environmental stress was positively related to poorer sleep quality and fatigue in our ro-ro sample. An obvious recommendation would thus be to reduce environmental stressors such as noise exposure levels in all living, recreational and dining areas, as well as to inform all seafarers about the potentially adverse effects of excessive noise and the correct use of noise protection equipment.

On the premise that previous experience with working in ICEs could familiarize seafarers with what to expect in terms of stressors in the environment, we wanted to explore the effect of seafaring experience on fatigue and sleep quality. Contrary to some previous studies [9], seafaring experience was not related to self-reported fatigue or sleep quality in our study. The regression analyses did admittedly reveal a statistically significant effect of experience on fatigue in the supply vessel sample, but this effect was so small that it should in reality be considered as practically insignificant. Perhaps the most interesting result from our study pertains to PsyCap. PsyCap turned out to be a robust predictor, with statistically significant relations to fatigue and sleep quality in both samples. The results from this study thus add to the existing knowledge of the relationship between PsyCap and perceived stress [32,33]. The qualities associated with PsyCap—resiliency and a sense of hope, optimism and self-efficacy—seem to equip seafarers with the necessary resources to cope with the stressful on-board environment. Optimistic individuals, for example, tend to make internal attributions for positive events and external attributions for negative events, and generally anticipate positive outcomes from their actions. Optimism, as well as hope, is also associated with a motivation to enhance efforts towards goals instead of disengaging and withdrawing efforts. Resiliency, in turn, is related to the ability to adjust positively to adversity, as well as to recover more quickly from failure and frustration. Combined, the psychological resources of optimism, hope, self-efficacy, and resiliency seem to equip seafarers with the necessary tools to handle the stress associated with working at sea, resulting in less fatigue and better sleep quality.

The results regarding PsyCap are especially interesting given that PsyCap is considered a malleable and open-to-development personal characteristic [16]. Empirical research has demonstrated that even on-line session and relatively short training interventions (1–3 hours) can be sufficient to increase individuals' PsyCap levels [34,35]. Interventions designed to develop PsyCap could therefore be a relatively easy and inexpensive way for maritime organizations to battle fatigue and poor sleep quality among their employees.

Another route to increasing the crews' PsyCap can be through leadership. While there still is limited knowledge about how PsyCap is formed and few studies address this issue, emerging research suggest that leadership perhaps plays an important role [36,37]. For instance, Hystad and colleagues [37] recently conducted a study on safety in the offshore oil and gas industry. Among other things, Hystad and colleagues [37] found that the leadership style known as authentic leadership [38] positively influenced follower PsyCap.

4.2. Limitations

The current study is cross-sectional and thus suffers from the usual shortcomings of this type of research. For one thing, causality is difficult to establish, as any firm conclusion about causality of course necessitates longitudinal and experimental research [39]. Our design is also unable to inform us about any intraindividual variation in fatigue and sleep quality during deployment. More studies employing diary-type methodology [40] are clearly needed to explore this issue.

Another potential limitation in the current study is the use of self-report, which of course relies on respondents giving truthful answers to the questions. Although our questions were not particularly sensitive in nature and all participants were assured about the confidentiality provided to them, there is still the possibility that some participants were reluctant to provide honest responses. It is possible that the levels of fatigue were underreported due to fear of negative repercussion from supervisors and management, especially for seafarers on temporary contracts.

The Cronbach α values for sleep quality and the environmental stressors measure in the ro-ro sample were relatively low (0.56 and 0.67, respectively). Although Cronbach α is the most widely known and reported indicator of a test's reliability, it is also known to give severe underestimates of reliability in many cases [41]. As a lower bound to reliability, Cronbach α should therefore be regarded as an overtly conservative estimate. Moreover, Cronbach α is also a function of the number of items in the test, with more items generally equaling higher α estimates. Given that the sleep quality measure contained three items and the environmental stress measure contained five items, this could go some way to explain the low α values.

5. Conclusion

In conclusion, our results point to psychological capital as a valuable positive resource for seafarers to cope with working in isolated and confined environment. Occupational fatigue represents a serious threat to the general health and wellbeing of workers, and in extension, can have severe consequences in terms of accidents and fatal disasters. Coupled with empirical research demonstrating that PsyCap is malleable and readably influenced by training interventions and leadership, our results suggest that maritime organizations could have much to gain by being cognizant of and developing routines for continually developing the PsyCap of their employees.

Conflicts of interest

Both contributing authors declare no conflicts of interest.

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