

Measurement of stress among marine engineers: a methodological intervention

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1. ABSTRACT: Stress measurement has been an issue on the backburner for maritime sector. In this sector, job related stress has been considered as a way of life. With the onset of pandemic, understanding stress and its management on board ships has become a challenge and of paramount significance to seafarers and shipping companies. Extended contracts of employment, constraints on ships, work fatigue, away from family have all highlighted the need for scientific research on understanding stress on board ships, particularly during challenging times.

Most of the studies on stress management and measurement among seafarers employ generalized stress management techniques which do not illuminate sector specific stressors, particularly during uncertain times like Covid-19, let alone illuminating general job related stressors. Lack of scientific understanding of stress and stressors in maritime sector adds on to this challenge and thus calls for a sector specific methodological intervention

to understanding of stress and stressors among seafarers. In this backdrop, based on previous evidences and discussion with seafarers, a methodology is developed to use a structured questionnaire covering stressors like job itself, company policies, planning activities, away from family, cultural differences and lack of socialization. Since pandemic posed dynamic constraints in the maritime ecosystem, such a structured questionnaire would help in understanding stress and stressor among marine engineers during Covid-19 and facilitate in the development of appropriate stress management strategies by firms in maritime sector. Reliability and validity of the questionnaire has been checked.

Keywords: *Likert scale, Questionnaire reliability, Cronbach's Alpha, Questionnaire validity, Allostasis load*

INTRODUCTION

Marine industry is one of the oldest industry and profession in human history. Such industry also led to not just new discoveries but also fostered integrated and more globalised world. However, working environment on board ships is not a smooth carpet. Resource constraints on ships and escalated demands from environment particularly during COVID-19 have resulted in staking health and well being of seafarer in terms of stress. Although provisions and regulations are in place to ensure ship safety, exclusive focus on the stress coping and management among seafarer has been at the back burner till COVID-19 set in. Although, adaptive behaviour to

stress is considered to be organic and part of jobs in marine industry, not addressing stress suitably may have negative health impact on the long run.

This is particularly true when stress coping strategies are so much inadequate in marine industry. In this context, the existing methodologies to study occupational stress may not be adequate to study the entire dynamics of stress and its management among seafarers. It is at this juncture, that this paper comes as an intervention to study stressors in marine industry in a sector specific framework using a questionnaire. The objective of this paper is to illuminate a questionnaire as an instrument that is prepared to understand stress among marine engineers exclusively during the time of uncertainty like COVID-19, outbreak of SARS virus, etc. Necessary statistical tests are conducted to ensure the suitability of the questionnaire for the said purpose.

The scope of the present paper is limited to marine engineering domain and not to entire seafarer community due to ease of access to understand the sector and thus understand level of stressors and stress. However, this questionnaire may be used for other categories of seafarers subject to achievement of statistical reliability and validity.

ORGANISATIONAL BEHAVIOUR IN ENGINE ROOM OF A SHIP

A ship comprises of Deck department, Engine department and Catering Department. Engine department is responsible for operational and maintenance of all ship board machinery and engineering equipment on board ship. Organisational structure in engine department is linear which comprises of Chief Engineer, Second Engineer, Third Engineer, Fourth Engineer, and Trainee. The Chief Engineer is the higher managerial role in the engine department essentially involved in managerial functions like planning, organising, directing concerning operational, repair and maintenance of machinery and equipment on board ship.

The second engineer reports his/her work to Chief engineer and is essentially involved in supervisory and operational roles. The second engineer's functional role is in line with a team leader who not just involved

in supervising operational and maintenance work of his subordinates but also has his operational roles. The second engineer is also part of engine room watch keeping along with other engineers. The third and fourth engineers are subordinates to second engineer. In some ship, trainee engineer is also hired and often taken on rolls to provide a first-hand experience of working on board to such employee. Such trainees are on board in a phase of learning by doing of their shipping career.

In terms of regulation effecting organisational behaviour in engine department, SOLAS chapter V illuminates safe manning principles as in the number of people required for safe operation of a ship. Thus, the number of people working on board depends on the nature of the ship like tanker, container ship, bulk carrier, and RORO vessel, etc. In practice, chapter III of the STCW convention which sets training, certification and competencies of personnel working in engine department on board as per safe manning. Further, the Ship Safety Management System which clearly draws job roles of human resource on board from safety perspective. Finally, the Maritime Labour Convention (MLC) which sets out labour practices on board which includes rest hours for personnel working on board, for instance, engine room. These provisions and regulations act as guiding yard sticks for ship owners and maritime administration i.e., flag state and port state controls for safe operation of a ship.

A close examination of the regulations and provisions highlighted earlier signifies that a competent crew is required to work for a specified period of hours to maintain safety on board. Therefore, these regulations are in place for the safety of the ship and not for the welfare of the seafarer. As Baumler (2020) illuminates that IMO's fatigue management approach essentially focuses on a safety of a ship rather than welfare of seafarers.

Further, the size and design of the ship puts much constraint. The design of the ship which may include compact engine rooms where there is not much free space to work for the marine engineers is itself acknowledged as one of the factors that makes crew work in inappropriate manner and staking not just their safety but all others on board (Lundh et al, 2011). Design constraints leading to adapting inappropriate operational

procedures and staking safety in engine room of a ship is also confirmed by Saatcioglu et al (2017). Moreover, working in engine room is quite daunting due to noisy environment, cramped space at the same time challenging demands due to technological innovations requiring engineer officers to be in line with such development (Man et al, 2018).

With the adoption of new technologies coupled with profit oriented motives, the size of the ships are increasing only to accommodate more cargo. Increasing load of cargo with a constrained number of engineering officers on board has increased the work pressure and work load of every engineer on board ships. Thus, following international safety regulations in view of constrained in terms of size of the ship, design of the engine room, limited number of personnel available to work have all lead to high level of stress (both perceived and actual) among engine room personnel. Such a tendency is confirmed by Oldenburg and Jensen (2019) who point out that on board a ship, engine room personnel are the second group after deck ratings that have highest occupational stress.

Therefore, work place stress is considered to be an organic part of marine engineering profession. This could be again due to the constraints on-board ship, any challenging demand from environment essentially has to be taken care by personnel working on board. For instance, if any machinery does not work at an expected level in mid sea, personnel working on board ought to come up with immediate solution which can be workable with the spares and equipment that are available on the ship till necessary help is available in the next port. To put it in other words, adaptive response to stress is part of marine engineer profession. It is in this context that this article borrows elements of work place stress from the perspective of Allostasis Load Model of Stress as propounded by McEwen (2005) who introduces a new terminology called allostasis refers to the adaptive bodily responses to stress.

He propounds that if the allostasis load is within limits, adaptive response to demands would occur. However, if allostasis "over load" occurs due to sudden unexpected demands from environment, this may lead to negative effects on human health. In marine industry, allostasis overload could be ship in a rough sea, extended

contracts during COVID-19, no shore leave and no crew change during COVID-19, etc. Though in marine industry, allostasis leads to adaptive behaviour to stress which is a long terms exercise (Todd, 2019), however, not addressing frequent occurrence of allostasis and particularly allostasis over load may lead to long terms impacts on health of marine engineers. This calls for remedial measures and coping strategies in place to handle such occurrence.

CAUSES OF STRESS AMONG MARINE ENGINEERS

Seafaring job is unique in nature and the factors affecting stress have particular characteristics different from other jobs (Anna Carotenuto et al, 2012). Research have shown that stress among seafarers in general is high. Separation from family is seen as affecting factor particularly for young seafarers having children (Oldenberg et al, 2009). Also, long hours of working results into increase in level of stress among seafarers (Oldenberg et al, 2019). Cultural differences among on-board employees may lead to understanding problem significantly (Simpson & Thompson, 2003) (Lu CS et al, 2012). Further, voyage planning (Elif Bal, 2015) and impact of lack of on-board socialisation, recreation, friendship on mental health of seafarers (McVeigh and Malcom, 2019) are also acknowledged as factors increasing stress level of on-board seafarers.

In the larger context of human resource management, Oldenberg and Jensen (2019), acknowledge that the stress level among seafarers varies based on policies followed by different companies.

RATIONALE FOR DESIGNING A NEW INSTRUMENT TO MEASURE STRESS

From the above discussion its apparent that spate of factors contribute to stress among marine engineers. In this context, instruments to measure level of stress like 'Perceived Stress Scale' (PSS) developed by Sheldon Cohen in 1983, 'Depression Anxiety Stress Scale' (DASS) developed by Lovibond, S.H., Lovibond, P.F. in 1995 are widely used till date. While the Perceived

Stress Scale is designed to measure the level of stress in general and classify them under categories like 'low stress', 'moderate stress' and 'high perceived stress'; the Depression, Anxiety and Stress Scale is designed to measure the levels of 'depression', 'anxiety' and 'stress' and categories them under 'normal', 'mild', 'moderate', 'severe' and 'extremely severe'. The existing instruments to measure stress taking into consideration critical lifetime events and their resulting stress on an individual. Such an analysis leads to a measurement of stress through perceptions based on previous experiences of depression, anxiety and stress.

However, when we talk about working professionals, talking about measuring work place stress is of significant importance to prescribe suitable stress coping strategies. Stress emanating out of critical life time incidents and level of work place stress are related. Stress measurement in the workplace is measured using established questionnaires particularly among health professionals. However, such methodologies result in subjective perception and therefore, an integrated approach of using data from various sources would be giving holistic understanding of stress (Guglielmi, et. al., 2013). The above instruments are used for sectors where the jobs are shore based. Thus, the constraints in the work place are not as significant as in case of marine engineering sector where the jobs are on-board ship based with less and timely access to resources, significant constraints and Covid-19 pandemic has further escalated these constraints and challenges.

Given the nature of the job in marine engineering sector on ships and specifically during Covid-19, applying the existing stress measurement methodologies in the form of DASS, PSS and questionnaires used among health professionals can't readily be applicable to marine engineering jobs.

Applying the existing stress measurement instruments to measure stress among marine engineers would lead to astrayed sense of stressors and levels of stress, and thus their respective coping strategies. In view of this, stress measurement among marine engineers requires a customized sector specific intervention to suitably measure and come up with effective stress coping strategies for marine engineers. In this context, the present paper follows a questionnaire based approach

exclusively designed for marine engineers which would account for the work place constraints of the sector and thus suitably measure stress and effectively prescribe stress coping strategies during uncertainties like Covid-19 pandemic. In the line of Guglielmi, et. al., 2013, we acknowledge that the result of such customized questionnaire based survey would be based on the perceptions of the working marine engineers towards various stressors and the resultant stress during Covid-19 pandemic and their individual stress coping strategies for the same. Nevertheless, given the scanty nature of scientific evidence, such an exercise would provide first hand information on stressors and levels of stress among marine engineers and thus would pave path for effective, responsive and adaptive stress coping strategies to uncertainties like Covid-19 pandemic.

In the above context, the present paper makes an attempt to design a questionnaire (as provided in Annexure 1) with a purpose of collecting data from marine engineers among all ranks to identify whether certain stress factors get augmented due to extraordinary situations like Covid-19 pandemic, attack of SARS virus, etc.

METHODOLOGY IN DEVELOPING QUESTIONNAIRE

A five-point Likert scale survey questionnaire has been designed initially consisting of 37 questions to identify stress factors like (i) job itself, (ii) planning, (iii) company policy, (iv) family affairs/away from family, (v) on-board socialization, (vi) on-board cultural diversity. The same was forwarded among working Indian marine engineers who sailed for a significant period during Covid-19 or experienced non-normal situations while sailing, like attack of SARS virus, etc. Out of the marine engineers to whom the questionnaire was forwarded, 100 responded. Based on the responses received, to establish linkages, the data was processed using IBM SPSS 23, Lisrel 8.8 and Microsoft Excel 2019.

Worthy illuminating here is that while developing a questionnaire, reliability and validity of the same should be tested. Only if a questionnaire is found reliable and valid, it may be used for collection of data and the results could be representative of real world scenarios.

In this context, reliability of a questionnaire refers to the extent to which the scores of the respondents are not affected by chance factors. A high reliability scored questionnaire doesn't produce significantly different results of one single respondent if the questionnaire is administered several times on him.

Cronbach's Alpha is most commonly used technique

to identify reliability of a Likert scale questionnaire. It was developed by Lee Cronbach to measure internal consistency (reliability) of a test or scale. Internal consistency refers to, the extent to which the items/questions of a scale/test measures same construct. It is expressed as a number between 0 to 1. The acceptable values of Cronbach's Alpha are shown in table 1.

Table 1. Threshold values of Cronbach's Alpha

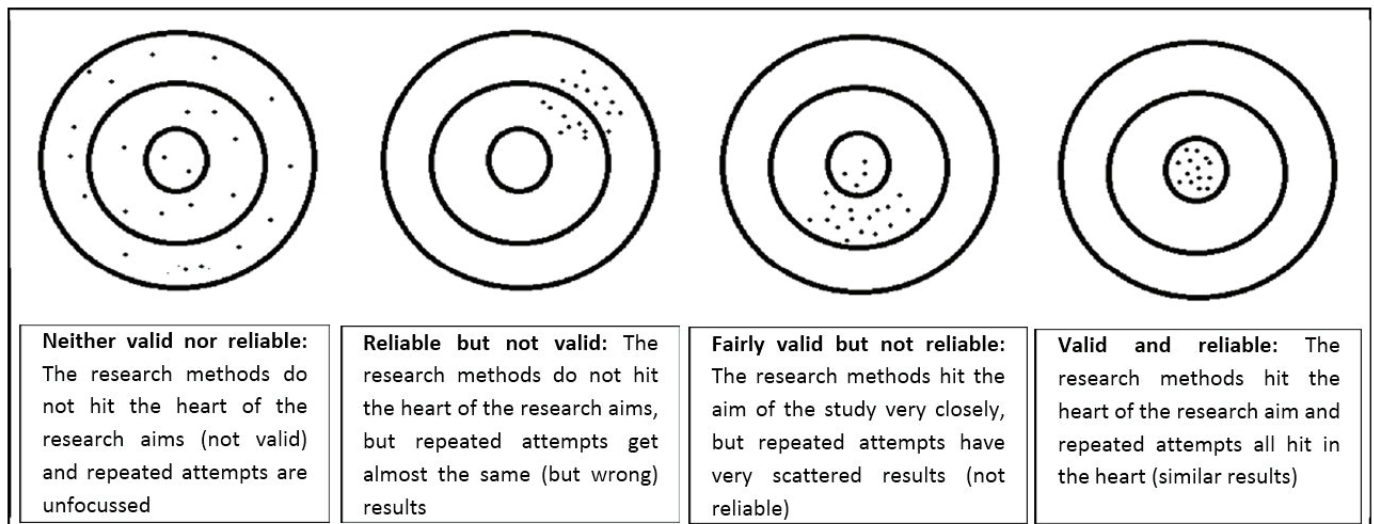
Cronbach's Alpha	Acceptability
≥ 0.90	Excellent
≥ 0.8 but < 0.9	Good
≥ 0.7 but < 0.8	Acceptable
≥ 0.6 but < 0.7	Questionable
≥ 0.5 but < 0.6	Poor
< 0.5	Unacceptable

Source: George, D., & Mallery, P.(2018)

On the other hand, validity refers to, the extent to which the questionnaire measures what it is supposed to measure. Testing of validity is an essential criterion towards construction of a valid questionnaire. Validity

may be measured by (i) face validity, (ii) content validity, (iii) convergent validity and (iv) discriminant validity. The concept and importance of reliability and validity is shown through fig 1.

Fig. 1. Illustration of Reliability and Validity



Source: Oladimeji Akeem Bolarinwa (2015)

Face validity: It denotes clarity, brevity and completeness of the questionnaire items/questions. The respondents have stated that they didn't face a difficulty in understanding the questions and the items/questions are comprehensive in nature.

Content validity: Content validity refers to the degree

to which the items of a questionnaire reflect a specific domain and can be measured using Content Validity Index (CVI). CVI can be measured by number of experts rate the items as per relevance to the study. The value of CVI lies between 0 to 1. The present questionnaire has been forwarded to four experts and everybody has rated is very relevant to the study.

Convergent validity: Convergent validity of a questionnaire is derived to determine whether the questions/items of a single construct/variable are associated closely or not. To assess convergent validity, Confirmatory Factor Analysis (CFA) was performed and thereby, Composite Reliability (CR) and Average Variance Extracted (AVE) were obtained and shown in table 4. While CR is intended to determine the consistency of construct validity indicator (Hamdan et al, 2011); AVE indicates how much variations in his items can be explained by the latent variable. Convergent validity is said to be achieved if the CR of a variable is higher than its AVE and the AVE is greater than 0.50 (Hair, 2009).

Discriminant validity: Discriminant validity explains whether the items of one construct diverge from another construct or not. It also measures the degree of differences between the overlapping construct (Hair & Ringle, 2014).

RESULTS AND DISCUSSION

As obtaining reliability of a questionnaire is the preliminary step towards making it useful, the cronbach's Alpha value of the questionnaire is obtained using SPSS 23 and the result is shown in table 2. The reliability of the questionnaire is found to be 'Good'.

Table 1. Overall Reliability Statistics

Cronbach's Alpha	No. of Items
0.882	37

Source: Authors own estimation based on the questionnaire self developed

After establishing reliability of the questionnaire, statistical validity of the same is also required to be established. Face validity and content validity helps to identify items unnecessary and ambiguous. It also indicates if any area of research is not covered through the questionnaire. In the present questionnaire, one item was found to be unnecessary and hence dropped.

While calculating Cronbach's Alpha, another item found to be not reliable and therefore dropped. Hence now, the modified questionnaire consists of 35 questions. Cronbach's Alpha of same is once again calculated and is shown in table 3. The reliability of the questionnaire after elimination of 2 item is also found to be 'Good'.

Table 3. Results of the Reliability Test

Latent Variables	Cronbach's Alpha	No of Items	Reliability status
Job itself	0.778	08	Acceptable
Planning	0.773	08	Acceptable
Company policy	0.862	07	Good
Family affairs/ away from family	0.903	04	Excellent
Lack of socialization	0.737	03	Acceptable
On-board cultural diversity	0.741	04	Acceptable
Overall Reliability	0.878	34	Good

Source: Authors own estimation based on the questionnaire self developed

In the present questionnaire, CR of each construct is higher than their respective AVEs. However, three constructs viz., Job itself, Company policies and On-board cultural differences have AVEs less than threshold values i.e., 0.50. According to Fornell and Larcker, the

convergent validity is still adequate even if the AVE is less than 0.50 but the CR is more than 0.60. As the CR of those three latent variables are well above 0.60, convergent validity of the questionnaire is established.

Table 4 . Composite Reliability and Average Variance Extracted

Variables	CR	AVE
Job itself	0.87	0.47
Company policies	0.84	0.44
Job associated Planning	0.87	0.59
Away from Family	0.99	0.95
On-board Culture differences	0.85	0.40
Lack of Socialisations	0.87	0.70

Source: Authors own estimation based on the questionnaire self developed

Fornell-Larcker criteria as suggested in 1981 used to be a popular way in establishing discriminant validity. In 2015, Henseler while disapproving the same, proposed Heterotrait-Monotrait ratio of correlations (HTMT). HTMT is found to be superior than Fornell-Larcker criteria and is able to achieve higher specificity and sensitivity (Hamid et al. 2017).

According to some authors (Clark and Watson, 1995;

Kline, 2011) threshold value of HTMT is 0.85 while some others propose 0.90 (Gold et al, 2001; Teo et al, 2008). Value of HTMT below threshold establishes discriminant validity for a construct.

HTMT of the questionnaire is undertaken and found that value of each construct is below 0.90 (table 5). Hence, the discriminant validity of the questionnaire is established.

Table 5. Results of Heterotrait – Monotrait ratio of Correlations

Constructs	Job itself	Job Planning	Company policy	Away from family	Lack of socialisation	Cultural difference
Job itself						
Job planning	0.86					
Company policy	-0.01	-0.15				
Away from family	0.29	0.36	-0.15			
Lack of socialisation	0.50	0.62	0.12	0.59		
Culture difference	0.20	0.46	0.08	0.46	0.41	

Source: Authors own estimation based on the questionnaire self developed

The reliability and validity status of the questionnaire is summarised in table 6 which essentially highlights that in terms of reliability test of the questionnaire, the results

of the Cronbach’s Alpha shows that all the constructs are above threshold value which necessarily qualifies the said questionnaire in the reality test.

Table 6. Summary of Reliability and Validity Statistics

Statistical procedure	Status	Conclusion
Cronbach’s Alpha	All constructs are above threshold value	Questionnaire is reliable
Face validity	The respondents didn’t face difficulty in understanding the questions	Questionnaire is valid
Content validity	The subject experts rated very relevant to the study	
Convergent validity	AVE and/or CR is above threshold levels	
Discriminant validity	HTMT values of all constructs are less than 0.90.	

Source: Authors own estimation based on the questionnaire self developed

In terms of validity, table 6 shows that the questionnaire prepared qualifies the test of validity in terms of face validity, Content Validity, Convergent Validity and Discriminant Validity that means the results from the survey thus obtained could be used to measure stress levels among marine engineers.

CONCLUSION

A generalised approach of measuring stress and understand stressors have been followed in literature on stress measurement. Research approaches to measure stress using established methodologies has been snowballing with time. With the on-set of COVID-19, such interventions are in their hay days. Given the nature

of environment in which job is taken place on board ship, maritime industry has been adding to research anxieties to understand stressors of this industry. Therefore, a sectoral approach rather than adopting existing methodologies to understand stressors is the need of the hour.

In this context, a questionnaire is developed to understand stressors and thus facilitate measuring stress levels among seafarers in maritime sector. The questionnaire thus developed also qualifies the reliability and validity test, thus focus on scientific rigour of such questionnaire which could be used to understand stressors and facilitate measurement of stress in future studies.

ANNEXURE 1

Table 7. Questionnaire to identify level of psychological stress among seafarers

Expectations from the respondents: In this section, the researcher tries to identify the factors responsible during onboard/extraordinary situations in increasing level of stress among the respondents. While going through the statements, please mark your response which comes spontaneously; please don't take much time to think and mark, as by doing that your responses may get biased. Remember, there is neither a right nor wrong response.						
Instructions: Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement. Strongly disagree(1), Disagree(2), Neutral(3), Agree(4), Strongly agree(5).						
J1	Do you agree that your job involves a high level of stress?	1	2	3	4	5
J2	Do you agree that due to extraordinary situations, time pressure for completion of work increases resulting into increase in stress level?	1	2	3	4	5
J3	Do you agree that your stress level further increases due to increase in job responsibility during the above-mentioned extraordinary situations?	1	2	3	4	5
J4	Do you agree that you need to work for more hours (than normal working hours) during the above-mentioned extraordinary situations?	1	2	3	4	5
J5	Do you agree that your stress level further increases due to overwork during the above-mentioned extraordinary situations?	1	2	3	4	5
J6	Do you agree that following the guidelines as per different rules/regulations (ISPS, ISM Code, etc.) during extraordinary situations becomes more stressful?	1	2	3	4	5
J7	Do you agree that on-board work environment (mixing/gossiping with others, etc.) becomes depressing during extraordinary situations like COVID-19 pandemic?	1	2	3	4	5
J8	Do you agree that your level of stress increases while working on-board during extraordinary situations like COVID-19 pandemic, outbreak of SARS virus, rough sea, etc.?	1	2	3	4	5
P1	Do you agree that seafarers run shortage of equipment on-board and that have an effect on furthering their stress levels during the above-mentioned extraordinary situation?	1	2	3	4	5
P2	Do you agree that during extraordinary situations, on-board job stress could be reduced by better planning either at company level or at on-board level?	1	2	3	4	5
P3	Do you agree that during extraordinary situations, planning for your on-board activities becomes more critical?	1	2	3	4	5
P4	Do you agree that 'Planning for on-board activities' during extraordinary situations becomes more stressful than normal period?	1	2	3	4	5
P5	Do you agree that being a seafarer you have to perform not only your core job activities (i.e., marine engineering activities) but additional multifarious activities also, which leads to increase in level of stress?	1	2	3	4	5
P6	Do you agree that performing multifarious activities further increases your stress level during extraordinary situations?	1	2	3	4	5
P7	Do agree that you feel more stressed as controlling/inspecting authorities (e.g. MMD in India, port authorities, etc.) of different nations plays more strict role than usual during pandemic/ extraordinary situations?	1	2	3	4	5
P8	Do you agree that lack of manpower on-board have an effect on further increase in stress level of seafarers during the above-mentioned extraordinary situation?	1	2	3	4	5
C1	Do you feel that your company provides adequate support to the on-board employees during extraordinary situations?	1	2	3	4	5
C2	Do you agree that you get adequate recognition from your company for accomplishing some difficult tasks on-board?	1	2	3	4	5
C3	Do you agree that you get adequate recognition (other than financial) from your company for sailing/overstaying on-board due to COVID-19 pandemic situation?	1	2	3	4	5

C4	Do you agree that your company’s view/policy regarding employee recognition is satisfactory?	1	2	3	4	5
C5	Do you agree that your company took adequate steps/measures to reduce level of depression among on-board employees?	1	2	3	4	5
C6	Do you agree that your company took adequate steps/measures to reduce level of stress among on-board employees?	1	2	3	4	5
C7	Do you agree that your company’s stand towards supporting on-board employees during extraordinary situations is depressive?	1	2	3	4	5
F1	Do you agree that during extraordinary situations, like COVID-19 pandemic, while on-board, you get depressed by thinking about your family/friends/close relatives?	1	2	3	4	5
F2	Do you agree that during extraordinary situations like COVID-19 pandemic, while on-board, you get stressed by thinking about your family/friends/close relatives?	1	2	3	4	5
F3	Do you agree that during extraordinary situations like COVID-19, if you get stuck on-board, being away from family and friends for longer period results into increase in level of your depression?	1	2	3	4	5
F4	Do you agree that during extraordinary situations like COVID-19, if you get stuck on-board, being away from family and friends for longer period results into increase in level of your stress?	1	2	3	4	5
CD1	Do you agree that your colleagues adequately recognize your accomplishment of some difficult task on-board?	1	2	3	4	5
CD2	Do you agree that on-board cultural differences increase your stress level?	1	2	3	4	5
CD3	Do you agree that due to cultural differences, working on-board with people of different nationality during extraordinary situations, becomes more stressful?	1	2	3	4	5
CD4	Do you agree that due to cultural differences, working on-board with people of different nationality during extraordinary situations, is more depressing?	1	2	3	4	5
S1.	Do you agree that due to inadequate level of on-board socialization among colleagues you feel more depressed than usual during COVID-19 pandemic situation?	1	2	3	4	5
S2	Do you agree that lack of shore leave during extraordinary situations like COVID-19 pandemic is having a major role with increase in level of depression among on-board employees?	1	2	3	4	5
S3	Do you agree that lack of shore leave during extraordinary situations like COVID-19 pandemic you feel more stressed?	1	2	3	4	5

Source: Authors self developed questionnaire

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