Assessing Occupational Stress in Seafaring: A Fuzzy Delphi Approach to Develop Effective Management Strategies in Offshore Support Vessel Operations

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The maritime industry has long been a crucial component of Malaysia's economy. Seafarers in this industry face unique psychosocial, work-related, and environmental stressors, which can negatively impact their health, safety, and well-being. The operations of offshore support vessels (OSVs) are particularly hazardous and require effective strategies for occupational stress management. The Fuzzy Delphi method was used to identify the key enablers of occupational stress in OSV operations. The study has found that the main enablers of occupational stress in seafaring include vulnerability towards occupational hazards and risks, human capital skills, onboard living conditions, governance capacity, and mental burnout. These findings can help guide efforts to address the occupational stressors faced by seafarers serving on OSVs and enhance their working conditions, skills, and health. Shipping companies, policymakers, and organisations must collaborate to ensure the compliance with marine regulations and standards, improve shift schedules, and implement proper mechanisms to maintain the occupational health of seafarers during and post the Covid-19 pandemic.

KEY WORDS
~ Safety and Health
~ Malaysian OSVs Seafarers
~ Occupational stress
~ Fuzzy DELPHI

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1. INTRODUCTION

1.1. Background

Ocean and coastal water transportation, better known as shipping, is one of the critical sectors in maritime industry (Cheryl R.K., 2015). Maritime industry been defined as anything related to the ocean, sea, ships, seafarers, ship owning and other related activities; while shipping business or sector, within the context of maritime industry, is the act of carriage of cargo from point A to point B, using ships (Hariesh Manaadiar, 2020). Shipping is vital to the world supply chain in the maritime cluster 9Othman, 2011). It provides a highly energy-efficient way of transportation of goods, such as chemicals, petroleum, textiles, and so on (M.B.C. Dorathy, 2017). Currently, more than 90% of the world's trade relies on shipping (IMO, 2019). Based on the International Chamber of Shipping (ICS, 2019), approximately 1647,500 seafarers are serving on international trading merchant ships. The safety and

security of ships at sea highly depend on the competence and professionalism of seafarers.

With an exponential growth in international trade, the number of ships and seafarers has increased dramatically over the years. Seafaring is a special profession as the working duration per trip is in general much longer than normal work, and the working environment is extremely constrained in comparison to on land jobs. Many studies pointed that occupational health, including both physical and psychological health, plays an important role in marine incidents and accidents (D. Shan, B. Neis, 2020). While we are paying exceptional attention to reduce the impact of shipping activities on the sea concerning sustainable development, the working conditions and occupational health of seafarers should not be neglected. To reduce the potential maritime accidents, minimalise the environmental and economic loss, ensure the decent work condition, and promote the well-being of seafarers for sustainable development, it is necessary to systematically investigate the occupational health of seafarers onboard offshore Support Vessel (OSV).

1.2. The Offshore Supply Vessel (OSV) and the Working Condition and Occupational Health of Seafarers

There are many types of ships/vessels designed for different purposes and functions, such as container ship, bulk carrier, tanker ship, Roll On-Roll Off (RORO) ship, passenger ship, naval ship, offshore support vessel, fishing vessel, special purpose ships, high speed craft and dredger (Raunek Kantharia, 2020); and offshore support vessel (OSV) is one of the vessel types that support upstream activities in oil and gas industries.

The history of OSV started in the mid1950s; where they start to use a supply vessel to support oil exploration at Gulf of Mexico (Bjornar Aas et al, 2009); and since then, OSV businesses has started to expand. There is a different type of OSVs which have served for different purposes, including seismic survey vessel, platform / straight supply vessel (PSV / SSV), anchor handling tugs, anchor handling tug and supply vessels (AHTS), utility vessel, fast crew boat, stand-by vessels, accommodation work barge / boat and others. Dependency of oil and gas industry upon OSVs is highly critical as it plays significant roles in ensuring required activities at offshore field which need to be executed. Among common roles of OSVs in offshore industries, one is to mobilise crew and offshore materials, to serve as an accommodation for offshore workers, to serve as standby boat at offshore field for the purpose of safety, security patrol and emergency preparedness, to perform anchor handling works and towing operations, and to support other oilfield activities during production, exploration, drilling, maintenance, diving, and survey operation. (Nurul Azni M & M Faiz M Azani; 2018), upstream shipping activities, such as exploration and development (Mohamad Rosni Othman, 2021). Roles and contributions of OSVs is highly desired to fulfil logistics need of upstream segment, which then will enable oil and gas extraction from seabed to be feasible. Being a part of the cycle in oil and gas industries, the presence of OSVs is much critical as one of the catalysts to spur the economy for the benefit and well-being of nations and societies.

Onboard OSV seafarers face high-risk working conditions. For instance, the adverse weather conditions, security threats, and high noise and vibration levels. The food supply can be limited onboard OSV. Strategies for improving food procurement for OSVs, emphasising the importance of advanced technology, comprehensive procurement procedures, qualified personnel, extensive logistics networks, and training programmes for food quality and safety need to be particularly addressed. These elements are critical to enhancing the quality of food for seafarers. In addition, seafarers lack exercise and recreational activities due to the shortage in space. Considering the emotional and psychological aspects, working onboard normally implies isolation from family members. Co-workers onboard normally change quite frequently and working as a seafarer requires a high level of resilience and adaptability, as they must constantly deal with the challenges of isolation and a changing workforce while performing their duties at sea. Despite all the challenges and risks faced by the seafarers at sea, occupational stress has been acknowledged as one of the contributing factors that cause impairment to the seafarer's health and well-being, potentially leading towards incidents (J. Rengamani & M. S. Murugan, 2012 and Ana Sliskovic & Z. Penezic, 2015). For instance, MT Exxon Valdez oil spill incident in 1989 was one of the catastrophic marine tragedies in history, closely linked with occupational stress issues. In fact, other than risk of incident, stress onboard vessel has also been acknowledged as a cause of severe depression and suicide among seafarers (Alex Mellbye & Tim Carter, 2017). UK Protection & Indemnity (P & I) Club in year 2017 had revealed that suicide was the top cause of seafarers' deaths, accounting for 15% of deaths at sea (Safety4Sea, 2019). Once in February 2019, Malaysia OSV industry has been shocked with one case of suicide committed by Sarawakian seafarer at Kemaman Supply Base anchorage, where his body was found hanged at the ship's side (Rosli Ilham, 2019). He was reported having a depression, but further investigation did not reveal what were the hidden causes underlying his action. Also, in Terengganu waters in July 2019, another case of suicide was reported involved foreign crew, where the his body was found hanged in the generator compartment of the ship. The vessel during that time was underway from Vietnam to Kemaman (Rosli Ilham, 2019). Due to these special working conditions on board OSVs, the potential impact on the occupational health of seafarers has raised the awareness across this sector.

1.3. The Occupational Stress of Seafarers Serving Onboard OSV

The issue of occupational stress among seafarers has garnered much attention from researchers, as the demands of the maritime industry, such as long working hours and trips, have been linked to negative impacts on the health of seafarers (Abaya et al., 2018). In addition, work-family conflicts and interpersonal conflicts among seafarers have been identified as factors contributing towards fatigue (Shan and Neis, 2020). Similar issues have been observed in other industries, such as manufacturing, construction, healthcare, and public services, where high workload, long working hours, and poor interpersonal relationships have been identified as common stressors.

A recent survey conducted by AIA Bhd., in 2019, as part of its "Malaysia's Healthiest Workplace by AIA Vitality" programme, found that Malaysian employees are facing significant levels of stress and sleep deprivation, with 51% of the 17,595 surveyed employees from 230 organizations reporting at least one dimension of work-related stress, and 53% getting less than seven hours of sleep in a 24-hour period. It is evident from these findings that occupational stress is a prevalent issue across various industries and requires a comprehensive solution, from both employers and relevant stakeholders.

The study aims at investigating the working environment and occupational stress of seafarers working onboard OSV (Offshore Supply Vessels) in the Malaysian shipping industry. The industry heavily relies on foreign seafarers, particularly from the Philippines and Indonesia, as shown by the data from the Malaysia Marine Department in 2017. Occupational stress among seafarers is a well-recognised issue in the high-tech shipping sector, and a proper understanding of the work environment and its relationship with occupational stress is crucial for the improvement of seafarers' health and well-being. Previous research has focused on individual factors affecting the life of seafarers, but a comprehensive study of the overall working environment and its impact on occupational stress is lacking. The research aims at filling this gap by exploring the issue of occupational stress among seafarers and offering strategies for identifying and reducing stressors in order to enhance the health and well-being of these workers.

1.4. Research Objectives

The main objective of the study is to investigate the occupational stress experienced by Malaysian seafarers working onboard OSVs and to identify effective strategies for managing this stress. The study is aimed at achieving this objective by conducting a literature review, collecting data through surveys and interviews with Malaysian OSV seafarers, analysing the data, developing evidence-based recommendations, and disseminating the findings and recommendations to relevant stakeholders. The study seeks to provide practical solutions for promoting better occupational health and well-being for Malaysian seafarers, with a particular focus on development of stress management strategies in dealing with stress in the unique context of working onboard OSVs.

2. LITERATURE REVIEW

ILO defined stress as the harmful physical and emotional response caused by an imbalance between the perceived demands and the perceived resources and abilities of individuals to cope with those demands. Work-related stress is determined by work organisation, work design and labour relations, and occurs when the demands of the job do not match or exceed the capabilities, resources, or needs of the worker, or when the knowledge or abilities of an individual worker or a group to cope are not matched with the expectations of the organisational culture of an enterprise (ILO, 2016).) The impact of stress has three categories which are physical health (such as fatigue, disordered eating, cardiovascular diseases, and musculoskeletal disorders), mental health (such as sleep disturbance, lack of concentration, emotional exhaustion, depression, anxiety, intolerance), and social health which will eventually lead towards interpersonal conflict (Ali M. Mosadeghrad, 2014).

Seafaring is known as one of the oldest profession of the mankind (Jabeth S.J.A Dacanay, 2003) and, like other professions in the world, it is not immune to occupational stress or work-related stress problems. Issues on occupational stress among seafarers is a global issue which has drawn the attention of many researchers. Marcus Oldenburg (2009) who id a study on seafarers serving onboard a German flag ship, and identified a few stressors. His studies found the separation with family to be the most significant stressor. Ana Sliskovic (2017), in her study of a number of Croation seafarers, said that occupational stress among seafarers could not even be compared with shore job due to a large number of stressors, risks, and challenges that the seafarers are facing, which could exacerbate their physical and psychological health. A study by M. Khairuddin Othman et. Al. (2015), conducted among the Malaysian seafarers, found that the element of working conditions, food/nutrition, and individual factors constitute the thee3 highest-ranking factors that could affect psychological condition. A few more factors that could influence occupational stress onboard OSVs have been identified: vulnerability towards occupational hazards and risks, mental burnout situation, onboard living condition, skill of human capital, and strength of governance capacity. Thereby the statement of Delphi has been developed to identify the main enablers towards reducing the occupational stress and developing the strategy for effective occupational stress management in OSV operation (See Table 1).

2.1. Vulnerability to Occupational Hazards & Risks (Safety, Health, and Security)

The term 'hazard' is closely interrelated with the term 'risk'; where risk is defined a combination of the likelihood of an occurrence of a hazardous event with a specified period or in specified circumstances, and the severity of injury or damage to the health of people, property, environment, or any combination of these caused by the event (DOSH, 2008). Seafaring is one of the occupations that expose an individual with various work-related hazards and risks, consisting of safety, health, and security hazards.

Among the emerging hazards and risks faced by the Malaysian seafarers onboard OSVs are adverse weather conditions (IMO, 2007), COVID-19 pandemic exhaustion (IMO, 2020), and fear and maritime security threats (Ana Sliskovic, 2017; AGCS, 2020). All those hazards and risks will create a stressful situation to the seafarers, due to the greater risk that they need to bear if it not properly been tackled, where the consequences could even lead to life threatening situations.

2.2. Mental Burnout Situation

The mental burnout classifies as an occupational phenomenon, not as a medical condition (WHO, 2019). The body burnout is defined as a syndrome resulting from chronic workplace stress which not been successfully managed where it has been characterised by three dimensions, including feelings of energy depletion or exhaustion, increased mental distance from one's job or feelings of negativism or cynicism related to one's job and a reduced professional efficacy. People with signs of burnout will feel the following emotion: every day is a bad day; caring about work or home life seems like a total waste of energy; exhausted all the time; the majority the day spent on the tasks feels either mind-numbingly dull or overwhelming; and, feel like nothing you do makes a difference or is adequately appreciated (HelpGuide, 2021).

Onboard OSVs, there are a few stress factors that might cause the seafarers to feel mental burnout, comprising shift work and sleep deprivation (ILO, 2004; M. Safahani, 2008; Anna Carotenuto et al, 2012; Jorgen R. Jepsen et al, 2015; H. Simkuva, 2016), excessive workload (Shoaib Raza et al, 2017; Jorgen R. Jepsen et al, 2015; Angelo U.P & Olympio B.G., 2017; Rajan D, 2018; G. Shigenaka, 2014; Angelo U.P & Olympio B.G, 2017; H. Simkuva et al; 2016), and shipboard conflict (Derek Farnswoth et al, 2019; Zeljko Turkalj et al, 2008; Ahmed A. Isa, 2015; Helen Sampson and Neil Ellis, 2019; Johnie J. Allen and Craig A. Anderson, 2017; Zeljko Turkalj et al, 2008; Helen Sampson and Neil Ellis, 2019; Rob Parkin,(2016). Hence it is very important to create a positive job atmosphere on board OSV and implement and embrace the standard workers' safety and health to reduce the level of occupational stress.

2.3. Onboard Living Conditions

Decent living condition is one of the seafarer's rights, as has been proclaimed and spelled out under Maritime Labor Convention (MLC, 2006), and the concern about the subject has not only drawn attention to the seafarers alone, but also to other stakeholder such as regulators, charterers, seafarers' unions, etc. One of the maritime bodies that have interest in this are Port State Control (PSC) authority. Port State Control Committee of the Memorandum of Understanding on Port State Control in the Asia-Pacific Region is the authorised body overseeing port State control regime in the Asia-Pacific region (Tokyo MOU, 2019) and Malaysia is one of the full members of the body.

Based on the Tokyo MOU 2019 Annual Report, 74, 550 deficiencies have been recorded and 9.62%, or 7, 171 out of the number is related to working, living, and labour conditions. Hence, based on the figures available, it may be concluded that crew welfare is among the common instances of negligence committed by ship's operators, which requires the fullest attention of all interested stakeholders. Among the common issues in seafarers' welfare aspect are access to online communication (Thu N. Yen, 2018; Anna Carotenuto, 2012; Angelo U.P & Olympio B.G, 2017; J. Rengamani & M.S. Murugan, 2012), shipboard catering and food quality (Helen Sampson & Neil Ellis,2019; Marcus Oldenburg et al, 2013), as well as hygiene and housekeeping (MLC, 2006; Chonghua Xue & Lijun Tang, 2019).

2.4. The Skills of Human Capital

Human capital refers to the production factors, coming from human beings who create goods and services. People's knowledge, skills, habits, creativity, and social and personality attributes are part of the human capital that contributes towards the creation of goods and services. (marketbusinessnews.com, 2021). The seafarer is the most important human capital for OSV's company, as he is the one who runs and operates the ship's owner critical asset which is the ship itself. Managing human resources and finding a way to improve their motivation and reduce job stress is very important for an organisation in order to improve the performance of employees and organisations in the era of industrial society (Sri Harini, 2020).

Thus, among the aspect of human capital that needs to be explored regarding the occupational stress are competency and seamanship (Zeke Quezada, 2021; C. Kanellopoulos, 2014; R Hanzu-Paraza, 2016; Yixiong He et al, 2017), mental health or stress management associated training (Josie S M-Saville et al, 2017; Neil Ellis, 2019; ISWAN, 2020), as well as the competency

of shore-based staff (Anish Wankhede, 2019; IMO, 2010). These elements represent very important dimensions in reducing the level of the occupational stress in OSV operations.

2.5. The Strength of Governance Capacity

The governance capacity as the ability of societal actors to work together in order to solve collective problems, consisting of institutional capacity and governance performance (Thi K P Dang et al, 2015). The governance capacity refers to how occupational stress among Malaysian OSV's seafarers can be collectively managed at the shipowner or management levels, and other relevant stakeholders, such as maritime bodies, authorities, charterers, etc.

The elements of marine regulations and procedures (MLC, 2006; STCW, 2010; IMO, 2019), management leadership and commitment (Metin Bayram,2018; Dominic Cooper, 2015; Malaysia Standards, 2018), OSH management system / HSE Management System (ILO, 2011; Mark Hammar, 2019), safety and health committee (Thomas J. Bukowski, 2014), and extended support from seafarers' association (Louise Gaille, 2017 & Jenn Hagedorn et al, 2016) have been identified as a composition of elements that complement each other in governing and overseeing occupational health aspect and occupational stress issues among the Malaysian OSV's seafarers.

3. LITERATURE REVIEW

Based on the literature review and with the technical description of the occupational stress on Malaysian seafarers serving onboard offshore support vessels as the foundation, the present research aims at revealing the criteria of the of the occupational stress on Malaysian seafarers serving onboard offshore support vessels. The construct of the research dimension, based on five (5) major enablers and 17 sub-indicators, that has been developed based on the literature reviews, includes the main pillars comprising the following: vulnerability to occupational hazards & risks (safety, health, and security); mental burnout situation; onboard living conditions; skills of the human capital, and the strength of governance capacity. Therefore the dimensions listed reflect the consensus of the experts from all the participating surveys. A total of seventeen sub-indicators or items have been developed based on these five major enablers or indicators.

This study is a quantitative one, applying the Fuzzy Delphi Technique to obtain expert consensus on the main components of the occupational stress and to identify the position of each component of effective occupational stress management based on the experts' consensus. This method involves the use of fuzzy set theory, which has been incorporated into the classical Delphi method, where the Likert scale chosen by the experts will be converted to a fuzzy scale using fuzzy numbering consisting of binary terms (0, 1). This fuzzy numbering integration will produce three values, namely the minimum value (1), the most reasonable value (m), and the maximum value (u), to be chosen by the expert. This study uses questionnaires as instruments for obtaining quantitative data on the components of occupational stress. This questionnaire is based on the expert opinion and is used to meet the criteria and conditions of the Delphi fuzzy technique, which involves the use of mathematical formulas to obtain expert consensus. The instrument used by the researcher is based on the needs of the researcher. The data analysis Delphi statements questionnaires have been carried out based on the enablers and items (see Table 1).

Table 1.
The statement of Delphi based on enabler and item.

Item	Statements of Delphi
Enabler 1.0	**Vulnerability to occupational hazards & risks**
1.1	**Adverse weather condition**
1	Malaysian OSV's seafarers are vulnerable to adverse weather conditions and the phenomena exerting stress upon them.
2	Risk of OSV's incidents escalates during adverse weather; and the situation, if not well managed, could cause incident and even lead to life threatening situations.
3	Master Overriding Authority and Stop Work Policy act as a tool that give exclusive right to Master and crew onboard OSVs to apply appropriate measures when encountering heavy weather; even if the operation needs to be aborted and stopped.
1.2	**COVID-19 pandemic exhaustion and fear**

4	Malaysian OSV's seafarers are vulnerable to COVID – 19 pandemic and the situation caused exhaustion and fear to them.
5	COVID -19 pandemic has caused difficulty in sign on/sign off process, which in turn has caused prolonged shipboard services onboard.
6	Prolonged shipboard service is an underlying cause of mental and physical fatigue which could lead to incidents.
7	Malaysian OSV's seafarers shall be prioritised in COVID-19 programme due to their critical roles in the industry and greater exposure to pandemic risk.
1.3	**Maritime security threat**
8	Malaysian OSV's seafarers are exposed to piracy threats at Southeast Asia (SEA) waters and the situation could cause stress to them.
9	Apart from piracy attacks, Malaysia OSV's seafarers also need to deal with threat from foreign fishing vessel which illegally encroach upon oil platforms in the vicinity.
10	Compliance to ISPS Code requirement is crucial in dealing with maritime security threats.
Enabler 2.0	**Mental burnout situation**
2.1	**Shift work and sleep deprivation**
11	Shift work system is one of the stress factors to the Malaysian OSV's seafarers (watchkeeping personnel).
12	6 hours on-6 hour off is a common shift regime practice onboard OSV; and this practice will inevitably lead to sleep deprivation (Recommendation sleeping hours is 7 to 9 hours per night as per USA National Sleep Foundation).
13	Sleep deprivation is bound to affect seafarers' health (such as cardiovascular disorder, emotional distress and impair cognitive function and memory) and, what is even more concerning, it could lead to sleepiness in watchkeepers while performing their duty.
14	Employing additional watchkeepers will enable a better shift arrangement, allowing more convenient shift regime to be executed (i.e. 4 hours on / 8 hours off).
2.2	**Excessive workload**
15	Nowadays, Malaysian OSV's seafarers are dealing with the issue of excessive workload, additionally causing stress to them.
16	Demanding administrative tasks contribute towards excessive workload to Malaysian OSV's seafarers.
17	Employment of additional officers will undoubtedly reduce excessive administrative load to Malaysian OSV's seafarers.
18	Application of digital solutions will certainly reduce excessive administrative load to Malaysian OSV's seafarers.
2.3	**Shipboard conflict**
19	Shipboard interpersonal conflict is one of the stress factors to Malaysian OSV's seafarers.
20	Shipboard conflicts could cause health problems to the seafarers and, worse yet, it could cause the affected crew to act aggressively.
21	Few measures such as anti-bullying and harassment policies, training to officers to educate them in creating positive atmosphere and Ship Owner to provide confidential counselling services could considerably mitigate shipboard conflict issues.
Enabler 3.0	**Onboard living conditions**
3.1	**Access to online communication**
22	Malaysian OSV's seafarers lack access to online communication allowing them to have a constant communication with their family.
23	Long separation from family is a common stressor to OSV's seafarers, and the situations make them feel homesick.

24	Homesickness could potentially impair the physical, cognitive, and psychological functions of Malaysian OSV's seafarers (such as disruption in sleep and appetite, depressive mood, loneliness, and anxiety).
25	Good access to online communication would help Malaysian OSV's seafarers to reduce seasickness and improve their mental health and well-being.
3.2	**Food and shipboard catering**
26	Food/nutrition standards onboard could favourably affect Malaysian OSV's seafarers' psychological condition.
27	Despite of MLC 2006 provisions that guarantee seafarers' right to get quality food onboard, there is an occurrence where food served on board OSV does not meet the expected standard.
28	Onboard Complaint Procedure (as per guided in MLC 2006) is the appropriate way to address food issues onboard OSV.
3.3	**Hygiene and housekeeping**
29	Onboard hygiene and housekeeping aspect is crucial for seafarers to stay healthy and prevent diseases.
30	Frequent hygiene inspection conducted by Master will ensure cleanliness and housekeeping onboard vessel being kept at an optimum level.
31	Regular visit and inspection from ship management team will ensure vessel to be kept in a presentable state.
Enabler 4.0	**Skill of human capital**
4.1	**Competency and seamanship of Malaysian OSV's seafarer**
32	Competency is an important aspect for Malaysian OSV's seafarer, enabling him to cope with work demand and pressure.
33	Additional training enforced by charterer to Malaysian OSV's seafarers will enhance their knowledge and skills.
34	Good seamanship attitude, combined with competency and training, is a guarantee that the seafarers will be able to perform the job safely and cope with work demands and pressures.
4.2	**Mental health or Stress Management associated Training**
35	Training related to mental health or stress management is beneficial for Malaysian OSV's seafarers, helping them to improve their mental health and deal with the stress issues onboard.
4.3	**Competency of shore-based staff**
36	OSV's operation at sea cannot rely on Master and crew alone; instead, it requires fullest and solid support from shore-based personnel to ensure the ship to operate smoothly.
37	Having a pool of competent shore-based workforce, with a right attitude to overseeing and managing vessel operation at sea will ensure the fullest support that can be given to OSV's seafarers.
38	Shore-based staff shall be adequately trained, so that OSV's operation can be performed safely, efficiently, and within the time limit.
Enabler 5.0	**Strength of Governance Capacity**
5.1	**Marine regulations and procedures**
39	Compliance to STCW and MLC 2006 is one of the key factors that will ensure safe operation onboard OSVs.
40	MSC.1/Circular 1598 – Guidelines of Fatigue developed by IMO (sometimes incorporated in company's SMS) provides practical guidance to Malaysian OSV's seafarers in managing fatigue issues onboard.
41	Procedures from charterers, such as Petronas Technical Standard (PTS) and Marine Manual of Permitted Operation (MOPO), providing a guide to OSV's seafarers to perform the work safely; which indirectly will ease work pressure of vessel's crew to execute the critical tasks.
5.2	**Management leadership and commitment**
42	Management's leadership and commitment to OSH is the most important element to ensure OSH culture and a climate to be adapted to the organisation, including a OSV company and onboard vessel.

43	Top management in OSV company clearly portrays their leadership and commitment towards OSH in the policy.
44	OSV company is recommended to have Mental Health Policy, where the policy shall state company's vision regarding mental health.
5.3	**HSE Management System / OHS Management System**
45	Implementation of HSEMS / OHSMS (or equivalent) will enhance OSH standard in an organisation.
46	Implementation of HSEMS / OHSMS (or equivalent) will be able to mitigate occupational stress issues onboard vessel.
47	Adoption of HSEMS / OHSMS (or equivalent) will assist OSV company in complying with Regulation 4.3 – Health and Safety Protection and Accident Prevention, MLC 2006, and flag state laws.
5.4	**Safety and Health Committee**
48	Safety and Health Committee, with strong and visible support from top management and active worker's participation, will make an impact on OSV's safety and lowering the rates of injury and illness.
49	Safety and Health Committee is the good venue and platform to identify problems and find a resolution pertaining to issues of mental health and occupational stress onboard OSV.
5.5	**Extended support from Seafarers Union or Association**
50	Malaysia Seafarers union, i.e. IKMAL help Malaysian OSV's seafarers, contributes a lot towards safeguarding their rights, promoting mental care, and mitigating occupational stress.

3.1. Fuzzy Delphi (FD) Technique

The Delphi technique is a method of obtaining a consensus among a group of experts through a series of surveys. It was first invented in the 1950s and is widely used in social sciences research. The technique involves experts providing their opinions, which are then analysed and used to reach a consensus. The Delphi method is based on verbal expressions, but has limitations in accurately reflecting the experts' thoughts. A modified version of the Delphi technique, called the Fuzzy Delphi method (FDM), uses fuzzy numbers to better reflect human thinking. The FDM method involves two main components: the Triangular Fuzzy Number and the Defuzzification Process. The Triangular Fuzzy Number consists of three values (smallest, most plausible, and maximum) and is represented as a triangular graph. The FDM method can be used in a single round and provides a clear solution for ending the rounds of the Delphi technique. In addition, the FDM is a methodology used for consensus building and decision making in groups. It combines elements of the traditional Delphi method with the principles of fuzzy logic. The key points of the FD technique are:

- Group Decision Making: The FD technique is used to reach consensus among a group of experts or stakeholders on a particular issue or problem. The group provides their opinions and insights through multiple rounds of feedback and refinement.
- Fuzzy Logic: The FD technique incorporates the principles of fuzzy logic to handle imprecise, uncertain, and vague information in the decision-making process. This approach allows for a more nuanced and comprehensive evaluation of the information being considered.
- Iterative Process: The FD technique follows an iterative process where the experts provide their opinions and feedback, and this information is refined and consolidated in subsequent rounds. The process continues until a satisfactory level of agreement is reached among the experts.
- Expert Feedback: Expert feedback is a crucial component of the FD technique. The opinions and insights of the experts are gathered and analysed to reach a consensus on the issue under consideration.
- Flexibility: The FD technique allows for a flexible approach to decision making. It can be applied to a wide range of issues and can be tailored to the specific needs and requirements of the group.
- Confidence Intervals: The FD technique also calculates confidence intervals to provide a measure of the level of agreement among the experts. This allows the group to make more informed decisions based on the level of consensus reached.

There are two main things in the Fuzzy Delphi (FDM) method, namely the Triangular Fuzzy Number (Fig. 1) and Defuzzification Process. The Triangular Fuzzy Number is composed of the values 1, m, and u, where 1 represents the smallest value, m represents the most plausible value, and u refers to the maximum value. The three values in this Triangular Fuzzy Number can be seen in Figure 3, which shows a triangular graph against triangular values. Based on the diagram below, it is evident that these three values are also in the range 0 to 1, and it corresponds to a fuzzy number (Ragin, 2007).

Figure 1.
Triangular fuzzy number.

Given the membership function of triangular numbers, it is revealed that if x is between l and m, then the larger x is the larger its membership function is, so that for x=m, the membership degree is 1. If x is between m and u, the larger x is the smaller its membership function is and in x=u the membership degree is 0. Therefore, it can be said that the membership degree of x in the interval [l, m] is monotonically incremental and in the interval [m, u] monotonically decreases. If l = m = u, the fuzzy number will become a crisp number. Membership function of a triangular fuzzy number includes both left and right linear parts that are joined together at (m, 1). Triangular fuzzy numbers are formed based on partial information. Suppose when dealing with uncertain values, the smallest and largest possible values can be determined. Hence, the supporting interval [l, u] can be defined. If we can determine m as the most probable uncertain value, then the peak will be at (m, 1). Therefore, with three l, m, u, triangular fuzzy number can be generated, and its membership's function is written. Due to its simple mathematical operations, the computational efficiency of triangular fuzzy numbers is very high. Mathematical operations on fuzzy numbers F1 and F2 can be done simply as follows:

$$F_1 = (l_1, m_1, u_1) \quad (1)$$

$$F_2 = (l_2, m_2, u_2) \quad (2)$$

After fuzzy aggregation of experts' opinions, the values should be defuzzified. In different methods that are done with fuzzy approach, the researcher ultimately converts final fuzzy values into a crisp and understandable number. Typically, the aggregation of triangular and trapezoidal fuzzy numbers can be summarised by a crisp value, which is the best average. This operation is known as defuzzification. There are several and complex methods of defuzzification. One of the simple methods of defuzzification is represented by average triangular fuzzy numbers:

$$if\ F = (l, m, u)\ Then\ F = (L + M + U) / 3 \quad (3)$$

(Cheng et al, 2009; Hsu et al, 2010; Wu and fang, 2011)

In the defuzzification process, there is also a condition that must be met to indicate the acceptance of a specialist group for a component studied in which the expected use of the median value, known as the alpha-cut (α-cut) value, is used.

4. QUESTIONNAIRE OF EXPERTS

The fuzzy Delphi technique is a method of determining the importance of criteria and screening key criteria using a fuzzy approach. This method uses a single round to summarise and sort items and includes four steps: 1) identifying an appropriate spectrum for the fuzzification of linguistic expressions; 2) fuzzy aggregation of fuzzified values; 3) defuzzification; and 4) selecting the threshold and screening criteria. To collect and fuzzify expert opinions, an appropriate fuzzy spectrum is developed for the fuzzification of respondents' linguistic expressions. A common fuzzy spectrum, used is the triangular fuzzy number for a 5-point scale on the significance of criteria, is as follows: Very Important (0.75, 1, 1); Important (0.5, 0.75, 1); Moderately Important (0.25, 0.5, 0.75); Unimportant (0, 0.25, 0.5); and, Very Unimportant (0, 0, 0.25).

5. RESULTS AND DISCUSSION

5.1. Part I - Expert Demographic Insights

This study has involved eighteen experts. Most experts have 5-26 years of experience and are directly involved in maritime education, maritime service providers, maritime activities manager, maritime workers and port and shipping agents. Based on the argument presented by Creswell & Creswell (2017), it is explicitly concluded that experts who have served between five and ten years can be categorised as experts. These experts are also selected on a voluntary basis. The number of experts in this application of Delphi's Fuzzy Technique agrees with Jones and Twiss (1978), who stated the number of experts in Delphi studies to be between ten and fifty experts. It has also been asserted by Adler and Ziglo (1996) that the number of experts is ten to fifteen in the event of a high level of expert agreement and uniformity.

5.2. Part II - Finding the ranked enablers of the seafarer's occupational stress of the OSV operations

The Summary of pre-requisite requirements of the Fuzzy Delphi analysis has been shown in Table 2. The fuzzy number based on 5 Likert Scale: 1 = Very important (0.75, 1, 1); 2 = Important (0.5, 0.75, 1); 3 = Moderately Important (0.25, 0.5, 0.75); 4 = Unimportant (0, 0.25, 0.5); and, 5 = Very Unimportant (0, 0, 0.25). In the study, five main enablers, fourteen main criteria, and fifty items have been identified based on the literature. Using five-point Likert scale, ten experts' opinions are gathered to determine the importance of these criteria. Linguistic expressions Fuzzy number: Very Important (0.6, 0.8, 1); Important (0.4, 0.6, 0.8); Moderately Important (0.2, 0.4, 0.6); Unimportant (0, 0.2, 0.4); and, Very Unimportant (0, 0, 0.2).

The threshold "d" value is important in determining the levels of agreement among the panel experts upon the items. The data from this exercise has been entered onto a Microsoft Excel worksheet and analysed with the following formula:

$$d(m, n) = \sqrt{(1/3)[(m1 - n1)^2 + (m2 - n2)^2 + (m3 - n3)^2]} \quad (4)$$

The threshold "d" value is lower or equivalent to 0.2 (≤ 0.2), therefore it can be said the panel of experts have achieved their consensus on the items. The feedback form experts have been analysed to quantify the threshold value "d". From the FD analysis it has been found that the overall scores of the "d" value for 50 items is 0.161, which means it surpasses the requirement (≤ 0.2). To proceed to the next Fuzzy Delphi process it is necessary to determine the group consensus percentage. The consensus of the panel experts must exceed the minimum requirement of 75 percent before it can be submitted to the next process. From the results, it is evident that the overall percentage score for this process is 82 percent, which means the group agreement has exceeded the minimum percentage value by more than 75 percent. The decision whether to retain or discard some items that have scored low percentage values has been determined by the final process, that is determining or identifying the ∞-cut value or defuzzification value. In summary, the rejection of the items is due to not meet Fuzzy Delphi (FD) pre-requisites, as shown in Table 2.

Table 2.
Summary of pre-requisites requirements of the Fuzzy Delphi analysis.

Fuzzy Delphi pre-requisite	Findings
Threshold d value (item) shall be ≤ 0.2.	Out of 50 items as per questionnaire, 8 items: 1; 8; 11; 13; 15; 16; 23; and, 27 found with "d" value > 0.2. However, in overall threshold "d" value (construct) ≤ 0.2 that meet the FD criteria with average result is 0.161.
Expert consensus ≥ 75%.	Out of 50 items, 15 items: 9; 11; 12; 13; 15; 16; 18; 21; 22; 23; 24; 27; 28; 40; and, 43 do not reach 75% of expert's consensus. However, in overall construct, expert's consensus has been achieved 82% consensus agreement from the experts.
Fuzzy score value (A) ≥ 0.5.	Out of 50 items, 2 items are less than 0.5 (Item 11, 12).

5.3. Part III - Findings of the Key Components of the Seafarer's Occupational Stress Indicators of OSV Operation

The study has been aimed at determining the level of agreement among experts regarding the main components of occupational stress in OSV operations. These components have been selected based on expert recommendations and are considered crucial for OSV service providers to acknowledge and implement. The results seem to indicate that the first main component, enabler number 1, consisting of items 5, 7, 4, 6, 3, 2, 10, 36, 38 and 37, has received the highest level of consensus among experts (see Fig. 2). The second main component, enabler number 2, consisting of items 34, 32, 33, 35, 30, 31, 29, 26, 25, 39, and 41, has emphasised the significance of human capital skills. The third main component, enabler number 3, highlights the importance of onboard living conditions, such as items 30, 31, 29, 26, and 25, in reducing occupational stress. The fourth main component, enabler number 4, describes the strength of governance capacity and consists of items 48, 49, 42, 44, 45, 47, 46, and 50. Finally, enabler number 5, ranked fifth, addressed the issue of mental burnout and consists of item 20 and 19. 17 items,

including 1, 8, 11, 13, 15, 16, 18, 21, 22, 23, 24, 27, 28, 40, and 43, have been rejected due to the prerequisites of the Fuzzy Delphi method of accepting and rejecting criteria (see Table 4). These findings have implications for OSV service providers and can be connected to the previous research in the field of occupational stress and human capital skills.

Figure 2 shows the fuzzy score values that have been ranked based on expert consensus. Table 3 shows the ranking of each item in the main components of safety and health implementation. As it has been noted, different methods could be used for fuzzy aggregation and defuzzification of calculated values.

Table 3.
Defuzzification results of aggregated Expert's values.

Item	Threshold value (d)	Percentage of Expert's Consensus (%)	Average Fuzzy Score	Rank	Result	Item	Threshold value (d)	Percentage of Expert's Consensus (%)	Average Fuzzy Score	Rank	Result
1	0.213	78%	0.522	44	Rejected	26	0.151	100%	0.689	12	Accepted
2	0.153	100%	0.700	8	Accepted	27	0.226	72%	0.533	43	Rejected
3	0.151	100%	0.711	3	Accepted	28	0.128	61%	0.611	30	Rejected
4	0.172	89%	0.656	21	Accepted	29	0.151	100%	0.689	10	Accepted
5	0.132	94%	0.744	1	Accepted	30	0.153	100%	0.700	5	Accepted
6	0.172	89%	0.656	21	Accepted	31	0.153	100%	0.700	8	Accepted
7	0.145	100%	0.722	2	Accepted	32	0.181	89%	0.667	19	Accepted
8	0.204	83%	0.500	48	Rejected	33	0.158	94%	0.667	19	Accepted
9	0.113	72%	0.567	36	Rejected	34	0.153	100%	0.700	5	Accepted
10	0.158	89%	0.644	24	Accepted	35	0.147	94%	0.656	21	Accepted
11	0.272	22%	0.400	49	Rejected	36	0.181	94%	0.711	4	Accepted
12	0.181	44%	0.378	50	Rejected	37	0.151	100%	0.689	12	Accepted
13	0.219	72%	0.556	40	Rejected	38	0.151	100%	0.689	10	Accepted
14	0.192	78%	0.556	40	Accepted	39	0.153	100%	0.700	5	Accepted
15	0.204	44%	0.567	36	Rejected	40	0.096	72%	0.611	30	Rejected
16	0.238	39%	0.567	36	Rejected	41	0.151	100%	0.689	12	Accepted
17	0.158	89%	0.556	40	Accepted	42	0.145	100%	0.678	16	Accepted
18	0.151	56%	0.578	35	Rejected	43	0.151	56%	0.622	28	Rejected
19	0.151	100%	0.511	47	Accepted	44	0.091	78%	0.622	28	Accepted
20	0.179	89%	0.522	44	Accepted	45	0.106	100%	0.644	24	Accepted
21	0.128	61%	0.611	30	Rejected	46	0.064	83%	0.611	30	Accepted
22	0.198	44%	0.633	27	Rejected	47	0.085	83%	0.633	26	Accepted
23	0.238	39%	0.567	36	Rejected	48	0.145	100%	0.678	15	Accepted
24	0.136	56%	0.600	34	Rejected	49	0.166	94%	0.678	16	Accepted
25	0.145	100%	0.678	16	Accepted	50	0.200	83%	0.522	44	Accepted
	Condition of Triangular Fuzzy Numbers: 1. Trashold value "d" ≤ 0.2 2. Percentage of experts Consensus < 75 %		Condition of Defuzzification process 3. Fuzzy Score ≥α-cut value=0.5								Expert Consensus

The main enablers for occupation stress of seafaring have been ranked based on the Fuzzy Delphi analysis. Table 5 shows the summary of the main enablers' statements of the occupational stress that have been ranked based on the priority, consisting of the following:

1. Vulnerability to occupational hazards & risks;
2. Skills of human capital;
3. Onboard living conditions;
4. Strength of governance capacity; and,
5. Mental burnout situation.

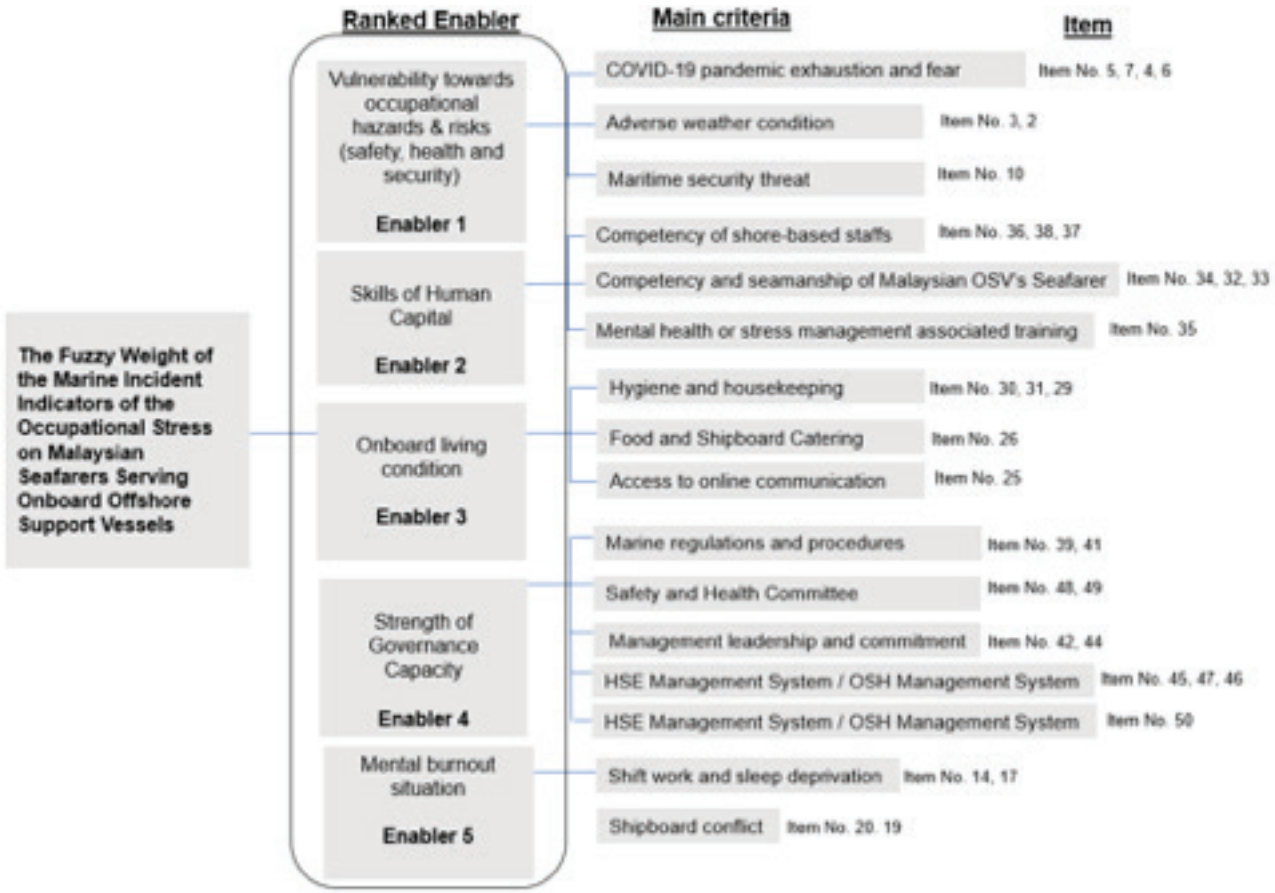

Figure 2.
Summary of the result of the main enabler or key components of the occupational stress using FD analysis.

Finally, the strategy of effective occupational stress management in Offshore Support Vessels (OSVs) operation can be developed using the Fuzzy Delphi results. The priorities implementation of the strategy are based on the ranking of these enablers, as summarised in the Fig. 2. The strategies are devised to improve maritime safety in the five key areas: vulnerability to occupational hazards & risks, skills of human capital, onboard living conditions, strength of governance capacity, and mental burnout situation. The strategies include identifying and mitigating hazards and risks, improving training programmes for seafarers, providing a safe and comfortable living environment, developing and enforcing regulatory frameworks, and addressing mental health issues. These strategies require a collaborative effort from all stakeholders in the maritime industry.

6. CONCLUSION

The researchers have found that the enablers and items agreed upon by the experts in the fuzzy Delphi analysis are essential for designing effective occupational stress management strategies in Offshore Support Vessel (OSV) operations. These enablers focus on reducing the vulnerability to occupational hazards and risks such as safety, health, and security. The experts have prioritised the importance of managing scheduling and

implementing Covid-19 Standard Operating Procedures (SOPs) to reduce the difficulty in sign on/sign off processes, prioritising Malaysian OSV seafarers in Covid-19 programs, increasing Covid-19 awareness programmes, and reducing the level of occupational stress. These enablers play a crucial role in reducing or mitigating occupational stress and ensuring compliance with Covid-19 protocols, improving safety and health standards in the maritime industry. The application of these strategies can lead to increased competitiveness and resilience in the shipping sector and provide a new dimension to the world's most pressing problems in the field of occupational stress management and Covid-19 compliance.

CONFLICT OF INTEREST:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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