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Table of Contents

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Hours of Work for Tugboat Operators

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Abstract

The purpose of this research was to review legal requirements, relevant government and professional organisation requirements for hours of work and fatigue management for tugboat crews in Australia. Results indicated that a general duty of care for the safety and health of employee and contractor tugboat crew was required by the employer. Risk control and mitigation recommendations related to hours of work, health and safety are included. It is also recommended that the health of employees, their levels of work related fatigue and fitness for work are monitored. The company has, and uses, a safety management and fatigue reporting procedure and has a just culture. The contribution of fatigue to reported incidents and accidents are assessed. Annual (or more frequent) employee interviews, employee survey and an audit are conducted to monitor the effectiveness of the rostered hours of work and the fatigue management risk control, mitigation and risk treatment measures used. Opportunities identified for improvements are implemented.

Key words: Tugboat crew. Hours of work. Fatigue management. Risk control.

1. Introduction

In June in 2014 in Western Australia at Port Headland there was an industrial dispute between the shipping company Tekay and the Maritime Union of Australia, the Australian Institute of Marine and Power Engineers and the Australian Maritime Officers Union. The reason for this dispute was that the tugboat engineers, deckhands and Master workers were working for as long as 18 hours with shifts beginning as early as 1.37am [01.37 hours] and not finishing until 9.56pm [21.56 hours] (Ker, 2014). They were called in to work when a ship was coming into the port, worked for several hours and then returned to their accommodation to wait for the next call to work. In 2014 the deckhands were earning about $140,000 and Masters were earning about $300,000 Australian a year. They had a roster of working for 28 days and then having 28 days off work. There was no annual leave or overtime payments and the tugboat workers were complaining that doing unpaid overtime work was having a negative health impact on their health and life (Ker, 2014).

2. Research method

In 2020 research was commissioned to develop fatigue management recommendations for a company that uses contract companies to supply vessel crews for tugboats use in Australian waters. Documents requested to be reviewed were Australian legal requirements for fatigue management and relevant government and professional guidance materials in relation to their recommendations on safe hours of work. Australian has 6 States and 2 Territories. Each state and territory has separate laws and jurisdictions that govern employer obligations in that state or territory that each business operates in. In addition to the above, there are Federal laws and marine jurisdiction laws that employers must comply with if the employer operates in trade or commerce in that jurisdiction. A review of relevant Codes of Practice, Guidance Notes and Guidelines for the Marine and other industries published by governments and professional organisations was conducted, in addition to the review of legislation, to determine each state, territory and federal jurisdictional requirements in relation to hours of work and fatigue management. A total of 27 Australian laws and 18 fatigue management and hours of work guidance documents were reviewed.

3. Results and Discussion

First reviewed was the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009, Petroleum (Submerged Lands) (Occupational Safety and Health) Regulations 2007 and the National

Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) Guidance Note for Avoiding Fatigue. A summary of these requirements were that the person who is in control should not allow a member of the workforce to work for a continuous period, or successive continuous periods of time that could have an adverse effect on their health or safety, or the health or safety of other people. (Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations, 2009, Chapter 3, Part 1, Regulation 3.1; Petroleum (Submerged Lands) (Occupational Safety and Health) Regulations, 2007, Regulation 27). This is an important legal requirement to consider when organising the hours of work for tugboat operators (NOPSEMA, 2020a).

The Western Australian (WA) Mine Safety & Inspection Act 1994; WA Occupational Safety and Health Act 1984; Northern Territory (NT) Work Health & Safety (National Uniform Legislation) Act 2011; Queensland Work Health & Safety Act 2011; New South Wales (NSW) Work Health & Safety Act 2011; Victorian Occupational Health and Safety Act 2004; South Australian (SA) Work Health & Safety Act 2012; Tasmanian Work Health & Safety Act 2012; Australian Capital Territory (ACT) Work Health & Safety Act 2011 and the Commonwealth Work Health and Safety Act 2011 all required the employer to have a general duty of care for their employees. If independent contractors are used all of these laws gave the company who employed the contractors the duties of an employer to the independent contractor in relation to matters over which the employer has control or would have control over. Part of this duty of care would relate to hours of work and fatigue management of the workers.

The Western Australian Occupational Safety and Health Regulations 1996 has regulations that apply to the hours of work for commercial vehicle drivers, but not for off shore workers. However this legislation, and the following legislation, all have requirements for the employer to identify hazards, assess the risks of these hazards causing harm and eliminate the risks of the hazards causing harm as far as is reasonably practical. NT Work Health & Safety (National Uniform Legislation) Act 2011 and the NT Work Health & Safety (National Uniform Legislation) Regulations 2011. The Queensland Work Health & Safety Act 2011 and Work Health & Safety Regulations 2011. The NSW Work Health & Safety Act 2011 and the NSW Work Health & Safety Regulations 2017. The Victorian Occupational Health and Safety Act 2004. The SA Work Health & Safety Act 2012 and SA Work Health & Safety Regulations 2012. The Tasmanian Work Health & Safety Act 2012; Mines Work Health & Safety (Supplementary Requirements) Regulations 2012 and their Work Health & Safety Regulations 2012. The ACT Work Health & Safety Act 2011 and ACT Work Health & Safety Regulations 2011. The Commonwealth Work Health and Safety Act 2011 and their Work Health and Safety Regulations 2011. Fatigue due to hours of work can be a hazard so all of the above legislation requires the employer to provide employees with hours of work that do not create a health or safety hazard. Similarly the Code of Practice. Working Hours published by the Commission for OSH (2006) and Bourgeois-Bougrine (2020) all required a risk management approach to managing employees' hours of work and fatigue.

The Victorian Occupational Health and Safety Act 2004 was the only Australian legislation assessed that specifically required the employer to monitor the health of their employees and keep health records (section 22). Section 35 of this legislation required the employer to consult with employees when making decisions related to workers health and/or safety. Australian legislation reviewed that did not have specific information in it related to hours of work and fatigue management was the Australian Maritime Safety Authority Act 1990; Port Authorities Act 1999; WA Mines Safety and Inspection Regulations 1995; Dangerous Goods Safety Act 2004; Victorian Occupational Health and Safety Regulations 2017 and the Tasmanian Mines Work Health & Safety (Supplementary Requirements) Act 2012.

Useful guidelines were the Australian Maritime Safety Authority Fatigue Guidelines, 2020, published by the Australian Government. It included reference to the Guidelines on Fatigue (MSC.1/Circ. 1598)

(2019) and Maritime Labour Convention (MLC), 2006. The following regulations are important to consider in relation to rostering hours of work for tugboat operators. Regulation 2.3: To ensure that seafarers have regulated hours of work or hours of rest. Regulation 2.4: To ensure that seafarers have adequate leave. Regulation 2.7: To ensure that seafarers work on board ships with sufficient personnel for the safe, efficient and secure operation of the ship. Regulation 3.1: To ensure that seafarers have decent accommodation and recreational facilities on board. Regulation 3.2: To ensure that seafarers have access to good quality food and drinking water provided under regulated hygienic conditions. Regulation 4.3: To ensure that seafarers' work environment on board ships promotes occupational safety and health. All of these Australian Maritime Safety (2020) guidelines are important to consider in relation to hours of work and fatigue management. Also included in this guideline was the International Labour Organization (ILO) Maritime Labour Convention (MLC), 2006, regulation 2.3 Hours of work and rest which states that the normal working hours' standard for seafarers shall be based on an eight-hour day with one day of rest per week and rest on public holidays. The limits on hours of work or rest shall be as follows:

(a) maximum hours of work shall not exceed:

(i) 14 hours in any 24-hour period; and

(ii) 72 hours in any seven-day period; or

(b) minimum hours of rest shall not be less than:

(i) ten hours in any 24-hour period; and

(ii) 77 hours in any seven-day period.

Hours of rest may be divided into no more than two periods, one of which shall be at least six hours in length, and the interval between consecutive periods of rest shall not exceed 14 hours.

Tugboat operators may be required to work long, irregular hours and on call hours (International Maritime Organisation, 2019). A reason that it is important to consider hours of work (which can affect the person's body clock circadian rhythms) and fatigue management is because not considering this can cause ill health effects as documented in table one.

Table 1. *Health effects of circadian rhythm disruptions that can be caused by irregular hours of work and/or by inadequate sleep (Maru, 2016, p.39-41).*

Health effects	Causes	References
Raised blood pressure	Low melatonin secretion & production of enough vasointestinal peptide that lowers blood pressure due to insufficient sleep time.	Bridger (2009) Kroemer (2008) Roberts (2010)
Headaches	Long working hours can cause static muscle loading and contraction of neck and shoulder muscles.	Sato et al., (2012)
Coronary Heart Disease and cardiomyopathic heart disease	Increase in parasympathetic nervous activity and increased blood pressure levels. Reduced parasympathetic nervous system activity with long working hours Poor eating habits develop due to sleep loss resulting in increase in Body Mass Index and Cholesterol level due to poor eating habits which increases cardiovascular risk. Chronic desynchronization of circadian rhythms	Sokejima & Kagamimori, (1998) Anujuo et al., (2015) Chung, et al., (2011)
Obesity	Sleep deprivation decreases leptin level and increases ghrelin levels. These hormones control the appetite, elevates appetite resulting in increased BMI. Unconventional meal times rather than routine meal times.	Scheer, Hilton, Mantzoros, & Shea, (2009) Markwald et al., (2013) Lee, Ng, & Chin, (2016)

Health effects	Causes	References
Diabetes	Inadequate sleep affects the molecular metabolism of the adipocytes causing a reduction in insulin production. Melatonin decreases glucose tolerance & this can occur if a person is eating when their circadian rhythm cycle is in normal sleep time. Impact on carbohydrate metabolism and endocrine function Sleep restriction disturbs energy balance via upregulation of appetite, increased time for eating and reduced energy expenditure. Nocturnal awakening and arousal alter leptin levels and leptin resistance leading to dysregulation of the HPA Axis resulting in glucose metabolism impairment.	Arble, et al., (2015). Spiegel et al., (1999); Barone & Menna-Barreto, (2011)
Gastro intestinal disorders	Decrease in Melatonin secretion and increase in inflammatory cytokine levels with inadequate sleep. Cause various types of autonomic nervous disorders due to a disturbance in circadian rhythm	Ali, et al., (2013) Segawa et al., (1987)
Prostate Cancer	The altered exposure to light-dark and feeding cycles causes desynchronization among internal timing systems that impact the temporal alignment of genetic and metabolic processes. Overexpression of Period2 gene (Per2) has tumour-suppressive properties. Lower expression levels of Per2 causes prostate diseases	Sigurdardottir et al., (2012)
Breast Cancer	Increased likelihood of light exposure at night and decreased length of sleep, both of which influence the circadian rhythm. Suppression of melatonin, a hormone capable of regulating the initiation, promotion and progression of cancer	He, Anand, Ebell, Vena, & Robb, (2015)
Endometrial Cancer	Less sleep decreases Melatonin secretion which lowers body immune responses and cell repairs.	Viswanathan, Hankinson, & Schernhammer, (2007)
Cognitive impairment	'Increased cortisol levels are closely related to cognitive defects in airline crews repeatedly exposed to jet lag' (p.588). Disruptions in circadian rhythm can lead to reduced brain temporal lobe size	Chung, Son & Kim (2011)
Poor mental health	Disruption in both melatonin (suppresses) and cortisol production (arouses) affect brain function. Poor mental health is caused by high need for recovery (more melatonin production needed) from fatigue and stress developed (high cortisol production) due to long working hours	van der Starre, Coffeng, Hendriksen, van Mechelen, & Boot, (2013)

Health effects	Causes	References
Lowered immune response to infections	Melatonin is produced when the body is at sleep. This hormone helps to reduce body's temperature, promotes an anti-inflammatory response, activates the immune system, and is an antioxidant. Inadequate sleep does not allow the production of adequate melatonin for these responses to occur adequately. Exposure to light can modify the immune response. Light of wavelengths more than 400 nm can penetrate through skin and interacts with circulating lymphocytes that modulate immune functions.	Bridger, (2009) Roberts, (2000)
Low fertility	Sleep loss causes a decrease inTestosterone production which reduces male reproductive fertility	Alvarenga et al., (2015)
Depression	Disrupted sleep stimulates the pacemaker in the hypothalamus of the brain. This can result in daytime production of melatonin that can cause difficulty in clear thinking, irritability and depression. Postmortem examination of people with depression identified that only 2 of 16 genes in the brain had a clear cycle pattern with the circadian rhythm flattened out and their body clock shifted by several hours or disrupted for the remaining genes.	Virtanen et al., (2011)
Fatigue	Chronic sleep loss causes fatigue	Golombek, et al., 2013. Niu et al., (2011)
Insomnia	With irregular hours of sleep-increased cortisol levels cause increased activeness and inhibits sleep at night.	Espie, (2002)
Anxiety	Increase in production of adrenal glucocorticoid due to longer waking hours can result in increased anxiety.	Chung, Son & Kim (2011) Samaha, Lal, Samaha, & Wyndham, (2007)
High blood cholesterol	Changed eating habits caused by sleep disruption increases blood cholesterol level	Anujuo et al., (2015)
Impaired cognitive function.	Desynchronization of circadian rhythm oscillators can affect neuro-behavioural functions and cause slower reaction times, increased variability in work performance, reduced vigilance, poor motivation, poor memory, increased errors, reduced learning ability, poorer decision making ability and reduced alertness. Chronic jet-lag is associated with a reduction in the size of the brain temporal lobe and increased cortisol levels.	Golombek, et al., 2013.

To complement and add to the information about hours of work and fatigue management Codes of Practice and guidance materials from the shipping and other industries that have shift

work were reviewed. NOPSEMA conducted a survey in March 2020 on variable work schedules: fatigue and psychosocial risk and published best practice responses for the people working offshore. Recommendations included fatigue assessments to be introduced for any personnel working over-cycle and ensuring high-risk work is avoided for the last week of the swing. For tugboat staff this would be week 4 of their 28 day work cycle.

The Safe Work Australia Guide for managing the risk of fatigue at work. Code of Practice (2013b) and Fatigue Management: A Worker's Guide (2013a) both emphasized meeting the legal requirements as documented in the Australian States and Territories legislation. There were also specific guidelines for shift work that included the requirement to plan an appropriate and varied workload. Offer a choice of permanent roster or rotating shifts and limit shifts to 12 hours including overtime, or to 8 hours if they are night shifts and/or the work is demanding, monotonous, dangerous and/or safety critical. Restrict number of successive night shifts to no more than 3 to 4 if possible. Shifts involving an early start should be shorter in length to counter the impact of fatigue later in the shift. If 12-hour shifts are worked then no overtime should be worked in addition. Avoid long working hours (more than 50 hours per week). Limit consecutive workdays to a maximum of seven. Allow a minimum of 12 hours between shifts as rest period between shifts should permit enough time for commuting, meals and sleep. Build regular free weekends into the shift schedule, advisably at least every 3 weeks. Use forward rotation (morning / afternoon / night) if there is a requirement for rotating shifts of work to cover a 24 business operation period. A shift design should take into account individual differences and preferences, allow individual choice where possible to accommodate family and other commitments, offer alternatives where workers have difficulty adjusting to shift times and keep the timing of shifts predictable.

In the aviation industry the International Civil Aviation Organisation (2016) manual for the oversight of fatigue management approaches, similar to Safe Work Australia's Code of Practice, made recommendations for having the timing of work shifts predictable and the type of work to be performed, as too high or too low a workload can contribute to an individual's level of fatigue. Other recommendations and information in relation to hours of work and fatigue management included when on call minimize interruptions during circadian rhythm times when sleep is more likely. Minimize continuous hours of wakefulness before and during duty periods that are unscheduled. The least amount of sleep is obtained before an early morning shift and ratings of fatigue are highest and performance poorest at the end of a night shift, regardless of the direction of shift rotation. Changes within patterns of work for operational personnel may have an impact on fatigue. An example of this would be rapid changes between work periods during the day and during the night. In order to avoid any detriment to individuals' performance, opportunities to eat, drink and meet biological needs were recommended to be provided. This recommendation is the same as that of the Australian Maritime Safety Authority Fatigue Guidelines (2020). Fatigue was found to be a contributing cause in incidents in the shipping industry that occurred between midnight and 6 am (International Maritime Organisation, 2019).

In the Fatigue Management. A Code of Practice for the Western Australian Taxi Industry (nd) published by the Department of Transport it stated that drivers should not exceed 14 hours of operation (including breaks) in any shift. Drivers should have a 10-hour continuous break in every 24 hours. This is the same recommendation as is in the ILO MLC (2006). Work time for drivers should not exceed 168 hours, spread over 12 days, in any 14-day period. If working a 28-day cycle the cycle there should be a minimum of four 24-hour breaks and it is preferable that the breaks are evenly spaced throughout the 28 days. If a driver works for 24 days without a break then he or she must take 4 days off. The last recommendations exceed the rest times provided in the ILO MLC (2006), requirements.

Similarly the Tasmanian Fact Sheet Fatigue management (2013) documented that it was important to ensure the roster provided for a continuous seven to eight hours of sleep in each 24 hours, at least 50 hours sleep for every seven days and ensure there was a minimum of

12 hours between consecutive work shifts. Other relevant recommendations were to allow short naps of up to 15 to 20 minutes during the shift if this fitted in with the type of work that was being done, and to avoid more than five consecutive early morning starts.

Unlike the shipping industry, the aviation industry makes a Safety Case to the Regulator that the risks of employee fatigue are controlled, that mitigation measures are used, that the effectiveness of fatigue management is monitored and is reviewed with audits and surveys. The aviation industry is required to have continuous improvement of the fatigue risk management through the elimination and/or modification of risk controls that had unintended consequences or that were no longer needed due to changes in the operational or organizational environment and to identify the need to introduce new processes and procedures to mitigate emerging fatigue-related risks.

The Australian Government Civil Aviation Authority (CASA) (2019) in the publication Fatigue risk management systems: A step by step guide, reported that aviation operators can submit a fatigue management safety case to CASA to demonstrate that they meet the International Civil Aviation Organisation standards. CASA recommended that airlines use a fatigue management system that includes:

(1) A fatigue Management Policy and Objectives.

(2) Fatigue risk management that includes identification and assessment of fatigue-related risks. Fatigue-related risk controls/mitigation/treatment. Implementation and evaluation.

(3) Fatigue risk management safety assurance that includes monitoring fatigue risk management effectiveness. Predictive, proactive and reactive monitoring to be conducted. Processes for managing change (to the operational/organisation environment and/or to the fatigue risk management system) were to be documented and there was to be continuous improvement of the fatigue risk management system where opportunities for improvements were identified.

(4) Fatigue risk management system promotion that includes training programs and a communication plan. The fatigue risk management system was to be part of the organisation's safety management system.

The United Kingdom Health and Safety Executive (2006; 2019) when providing advice about rostering hours of work and fatigue management recommended offering employees a choice of permanent or rotating shifts and try to avoid permanent night shifts. If there was a business need to rotate shifts do this every 3-4 weeks - otherwise adopt forward rotating shifts. Limit shifts to 12 hours including overtime, or to 8 hours if the work is night shifts and/or the work is demanding, monotonous, dangerous and/or safety critical. This was also a recommendation of Safe Work Australia (2013b). Encourage workers to take regular breaks and allow some choice as to when breaks are taken. Similarly this was a recommendation of the Maritime Labour Convention (2006). Health and Safety Executive (2019) stated that it was important to consider the needs of vulnerable workers, such as young or aging workers. Similar to Safe Work Australia (2013b) the Health and Safety Executive (2019) recommended to limit consecutive workdays to a maximum of 7 days and added to restrict long shifts, night shifts and early morning shifts to 2-3 consecutive shifts. Allow 2 nights full sleep when switching from day to night shifts and vice versa and build regular free weekends into the shift work schedule (Health and Safety Executive, 2006).

Also assessed was the United Kingdom Office of Rail Regulation guide for managing rail staff fatigue (2012) which promoted managing employee hours of work through having a policy, organising, planning, implementing, measuring, auditing and reviewing. Other information included that with the constant strive for improved efficiency, a significant contributory factor to fatigue can often be resource allocation and the availability of competent staff. If fewer competent staff are available, workload demands on individuals may rise, increasing the likelihood of fatigue. Organisational changes which could impact on staffing resources should be safety validated, and the validation process should consider risks from staff fatigue. Staff should feel able to cope with the demands of their jobs, and systems should be in place locally to pick up and respond to any individual concerns. The

organisation should provide staff with adequate and achievable demands in relation to the agreed hours of work. People's skills and abilities should be matched to their job demands. Jobs should be designed to be within the capabilities of staff. Employees' concerns about demands on them should be addressed. Minimum staffing levels for safety critical posts should, where possible, be specified and arrangements should include contingency arrangements for foreseeable abnormal conditions such as sickness absence, network disruption and emergencies. Employers should not rely on voluntary overtime arrangements to cover normal working periods – all duty hours of work should be covered in a planned way.

The United Kingdom Office of Rail Regulation (2012) documented that companies should have fitness for duty checking arrangements to ensure that staff reporting for safety critical work are not suffering, or likely to suffer during their shift, from fatigue. Such arrangements seek to identify any issues which may reduce the individual's ability to work safely including not only fatigue but any drug and alcohol use, illness or its after-effects, potential distraction or other psychological effects from any recent incident, work related or domestic problems. The system should seek to establish whether the individual has had sufficient sleep in the hours before starting work, such that they should be able to carry out their work safely for the whole of their shift. The system should identify not just whether the individual is fit at the start of the shift, but is likely to remain fit until the end of their shift – being awake too long before work greatly increases the risk of fatigue later in the work period.

There is evidence that human performance deteriorates significantly when people have been at work for more than 12 hours (Office of Rail Regulation, 2012). In a review of the relative risk of accidents or injuries, the risk of an incident was shown to increase with increasing shift length over eight hours. Relative to eight hour shifts, 10-hour shifts were associated with a 13% increased risk, and 12-hour shifts with a 27% increase. hours (Office of Rail Regulation, 2012). This finding was similar to that of the International Maritime Organisation, (2019) who documented that long work hours were associated with poor performance, higher injury rates, and poorer safety and health outcomes (both mental and physical) and that accident rates rise exponentially after 12 hours of consecutive work, particularly when working at night. Good practice for maximum shift lengths would be day shift – twelve hours; night and early shifts – ten hours and shifts starting before 0500 - eight hours. It was recommended to include a minimum rest period of 12 hours between consecutive shifts, increasing to 14 hours rest in the case of consecutive night shifts hours (Office of Rail Regulation, 2012).

People differ in their ability to adapt to and tolerate shift work. For instance, studies of ageing and the ability to cope with shift work have suggested that older workers generally cope well with the demands of early shifts but may experience more difficulties with the night shift – with ageing there is a tendency to become more of a 'lark' (waking earlier and most alert in the first part of the day) than an 'owl' (waking later and most alert later in the day or evening). When allocating individuals to particular shift patterns, employers should make reasonable efforts to accommodate personal preferences, some of which may stem from such trends in shift work tolerance. Staff should be consulted on the proposed working patterns, their views on fatigue risk aspects considered and soon after its introduction, ask staff about how tiring they find the working pattern in reality (Office of Rail Regulation, 2012).

Tasks that require sustained vigilance, or where the employee may have low levels of workload, may be more susceptible to fatigue. The timing of breaks is important. General advice for tasks that require continuous sustained attention, with no natural breaks in the task and where a lapse in attention can lead to safety implications, is for a regular 10-15 minute break every two hours during the day and every hour during the night. In the case of safety critical workers on night shift, the facility to take a short nap during a break can be especially beneficial. Naps of no more than 10 minutes are advisable if safety critical tasks are to be resumed within 20 minutes of waking. This is to avoid any grogginess on waking from a nap (sleep inertia) (Office of Rail Regulation, 2012). The International Maritime

Organisation, (2019, p.9) documented that when a person 'is woken up suddenly, the brain can have difficulty transitioning out of deep sleep. This sleep inertia causes feelings of grogginess and disorientation, with impaired short-term memory and decision-making, and can last longer than 30 minutes. Sleep inertia can also occur following lighter sleep, but it tends to be longer and more disorienting when someone is woken abruptly out of deeper sleep.' This is important to consider if tugboat staff are on call and have an opportunity to sleep between bringing ships into port.

4. Conclusions and Recommendations

The Federal Government, all Australian States and Territories have legislation that requires a general duty of care for employees and for the company to conduct risk management in relation to hours of work and fatigue management.

For best practice in fatigue management, and to meet minimum requirements for contractor vessel crews, it is recommended that the following should be included.

- Normal working hours should be an 8 hour day with at least one day (24 continuous hours) of rest every 7 days. There is evidence that human performance deteriorates significantly when people have been at work for more than 12 hours so hours of work on any one day should not exceed 12 hours (Australian Maritime Safety Authority Fatigue Guidelines, 2020; ILO Maritime Labour Convention, 2006; Office of Rail Regulation, Managing rail staff fatigue, 2012).
- Have an adequate number of competent staff for the safety and security of work functions (Australian Maritime Safety Authority Fatigue Guidelines, 2020; ILO Maritime Labour Convention, 2006; Office of Rail Regulation, Managing rail staff fatigue, 2012)
- Tugboat crew to have regulated hours of work and rest functions. Keep timing of shifts predictable. (Australian Maritime Safety Authority Fatigue Guidelines, 2020; Safe Work Australia, Guide for managing the risk of fatigue at work. Code of Practice, 2013)
- Minimum hours of rest shall not be less than 10 continuous hours in any 24 hour period and 77 hours in any seven day period (Australian Maritime Safety Authority Fatigue Guidelines, 2020; ILO Maritime Labour Convention, 2006; Fatigue Management. A Code of Practice for the Western Australian Taxi Industry. Department of Transport, nd.)
- Consult with employees about their hours of work and proposed work patterns. Give employees reasonable opportunity to express their views and take into account their views (Victorian Occupational Health & Safety Act, 2004; Office of Rail Regulation, Managing rail staff fatigue, 2012).
- A shift design should take into account individual differences and preferences as far as possible (Safe Work Australia, Guide for managing the risk of fatigue at work. Code of Practice, 2013; Office of Rail Regulation, Managing rail staff fatigue, 2012).
- Have access to good quality food and water. Opportunities to eat, drink and meet biological needs must be provided (Australian Maritime Safety Authority Fatigue Guidelines, 2020; ILO Maritime Labour Convention, 2006; International Civil Aviation Organisation, Manual for the Oversight of Fatigue Management Approaches, 2016).
- Encourage workers to take regular breaks and allow some choice as to when they are taken (Health & Safety Executive, 2019).
- Too high or too low a workload can contribute to an individual's level of fatigue so the monitor workload of individuals (International Civil Aviation Organisation, Manual for the Oversight of Fatigue Management Approaches, 2016; Office of Rail Regulation, Managing rail staff fatigue, 2012).
- Monitor the health of employees, their levels of work related fatigue and fitness for work (Safe Work Australia, Guide for managing the risk of fatigue at work. Code of Practice, 2013; Victorian Occupational Health & Safety Act, 2004; Office of Rail Regulation, Managing rail staff fatigue, 2012).

This research was carried out for an employing company to also check that any contractor companies that they hired to supply and

manage tugboat crew had legally compliant hours of work for their tugboat crew, had effective fatigue management strategies in place, that the effectiveness of the rostered hours of work and fatigue management were monitored and improved as required. The document in Appendix one, based on the review of legislation, codes of practice and other guidance materials, has been designed as a tool to achieve this.

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Appendix 1.

Hours of Work and Fatigue Management.

It is a requirement of the Work Health & Safety Act and Regulations that the occupational health and safety of all employees are cared for and that the risks of harm to their health and safety are reduced to as low as is reasonably practical. To demonstrate that your company will meet these requirements in relation to hours of work and employee fatigue management please answer the following questions with yes or no and provide the reason for your answer next to the word explanation.

Hours of work

1. Employee normal work hours are an 8 hour day with at least one day (24 continuous hours) of rest every 7 days. Yes [] No []
Explanation _____

2. Employee work hours on any one day do not exceed 12 hours. This includes on call and overtime work hours. Yes [] No []
Explanation _____

3. Minimum employee hours of rest are not less than 10 continuous hours in any 24 hour period and 77 hours in any seven day period. Yes [] No []
Explanation _____

4. Timing of work shifts are regular and predictable. Yes [] No []
Explanation _____

5. Employees are consulted about their hours of work and proposed work patterns with employees given the opportunity to express their views and these views are taken into account. Individual differences and preferences are accommodated as much as possible. Yes [] No []
Explanation _____

Occupational Health & Safety.

1. An adequate number of competent staff for the safety and security of work functions are rostered to work at all work times. Yes [] No []
Explanation _____

2. Workers are provided with regular scheduled breaks and are allowed some choice as to when their breaks are taken. Yes [] No []
Explanation _____

3. During their work time employees have access to good quality food and water. Opportunities to eat, drink and meet biological needs are provided. Yes [] No []
Explanation _____

4. Workload of individuals is monitored to ensure that it is not too high or too low. Yes [] No []
Explanation _____

5. Training and education on fatigue management and reporting is provided to employees. Yes [] No []
Explanation _____

6. The company has measures in place to enable employee recovery from fatigue and for mitigation of the effects of fatigue. Yes [] No []
Explanation _____

7. The risk management and other relevant requirements of the Western Australian Code of Practice. Working Hours (2006) are met in relation to hours of work and fatigue management. Yes [] No []
Explanation _____

Monitoring and Improving

1. The health of employees, their levels of work related fatigue and fitness for work are monitored. Yes [] No []
Explanation _____

2. The company has, and uses, a safety management and fatigue reporting procedure and has a just culture. Yes [] No []

Explanation _____

3. The contribution of fatigue to reported incidents and accidents is assessed. Yes [] No []

Explanation _____

4. Annual (or more frequent) employee interviews, employee survey and an audit are conducted to monitor the effectiveness of the rostered hours of work and the fatigue management risk control, mitigation and risk treatment measures used. Opportunities identified for improvements are implemented. Yes [] No []

Explanation _____

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Safety Committee Tool-Its Effectiveness in Nigeria Industries

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Abstract

This research considered the effectiveness of Safety Committees in industries in the Delta State, Nigeria. The study assessed the level of safety committee effectiveness in oil and gas, construction and flour Mill Companies. Survey questions were adopted from the National Health and Safety Division (2018), Oregon Occupational Safety and Health Administration Guidelines (2014) and Ontario Guide on Workplace Health and Safety (2011). This questionnaire was distributed to the companies understudy to collect data. The overall purpose of this study was to evaluate the application and effectiveness of safety committees in the oil and gas, road construction and flour mill companies (three companies from each sector; Oil and Gas Companies (A,B,C), Construction Companies (D,E,F) and Flour Mill Companies (G,H,I) in Delta State using the safety committee audit tool. The results indicated that the application and effectiveness of safety committee in companies A, B, C on the average were 74%, 67% and 64%. In companies D, E, F it was 57%, 62%, 55% and companies G, H, I were 81%, 74% and 0% (because information was not provided by company I which showed non application of safety committee in that company) respectively. Companies A, B, C, G and H performed within an acceptable range. Since the effectiveness of safety committee for company "D"," E"," F" were low, it was recommended that an internal audit be conducted twice a year using the National Health and Safety Division, Safety Committee Audit Tool. The companies have communication problem and managements should be committed to improve this vital indicator.

Key words: Safety Committee, effectiveness, Audit Tool, Guideline

1. Introduction

The construction industry is an important part of the economy in many countries and often seen as a driver of economic growth, especially in developing countries. Typically, construction industry contributes to 11% of Gross Domestic Products (GDP) in most developing countries (Giang and Pheng, (2010). However, many construction activities are inherently health and safety risks such as working at height, working underground, working in confined spaces and close proximity to falling materials, handling loads manually, handling hazardous substances, noises, dusts, using plant and equipment, fire, exposure to live cables, poor housekeeping and ergonomic miss match hazards. The construction industry has therefore earned the reputation of being a dangerous or highly hazardous industry, because of the disproportionately high incidence of accidents and fatalities that occur on construction sites around the world (Smallwood *et al*., 2008; Newman, 2017). Internationally, construction workers are two to three times more likely to die on the job than workers in other industries while the risk of serious injury is almost three times higher. Health and safety therefore are economic as well as humanitarian concern that requires proper management risk control. One of the most common myths that has plagued this industry is that workplace health and safety comes at a cost. Construction managers tend to believe that introducing and executing measures that ensure health and safety in the construction sector will lead to higher cost, and hence lower profitability. It has been proven that investment

in construction health and safety actually increases the profitability by increasing productivity rates, boosting employee morale and decreasing attrition (Muiruri and Mulinge, 2014).

The promotion of safety and health at work is not only a function of good management but it is, or ought to be, a normal management function. Safety and health objectives should be effectively incorporated into a company's overall management system along with other management objectives such as production and quality control. If standards of safety and health at work are to be improved, full co-operation and commitment of all employees are absolutely essential.

All employees must be able to participate fully in the making and monitoring arrangements for safety and health at their place of work in order to arouse their interest in accepting their full share of responsibility. The appointment of a safety committee is one of the methods of increasing the involvement and commitment of employees. Given the diversity of operations and variability of workplace hazards, safety committees will need to be developed to take full account of all the relevant circumstances (Amund *et al.,* 2014; Canada Center for Occupational Health and Safety Council (CCOHS), 2018).

There are numerous safety and health hazards associated with grain handling operations, among them suffocation and falls are the two leading causes of deaths. Other hazards include fires, explosions, and injuries from improperly guarded machinery. Exposure to grain dust and associated airborne contaminants can also occur. Such contaminants include molds, chemical fumigant and gases associated with decaying and fermenting silage.

Health and safety have continued to be a priority issues for the Nigeria oil and gas industry, as they are pertinent to other sector's overall success. Multinational oil companies operating in Nigeria have been criticized severely by both local and international pressure groups for engaging in unwholesome health, safety and environmental practices; resulting in widespread ecological disturbances, including pollution from pipeline leaks; blowouts; drilling fluids and refinery effluents; land alienation; and disruption of the natural terrain during oil and gas operations (Ibebuike, 2018).

Since the 19th century, workers have been organized in trade unions and parties to strengthen their efforts at improving workplace health and safety, job conditions, working hours, wages, job contracts, and social security. Cooperation between workers, worker organizations and occupational health professionals is widely believed to be instrumental in improving regulation and legislation affecting workers' health. The theory behind requiring joint worker-employer health and safety committees is that a safer workplace is best achieved through empowering workers and managers to ensure that standards and regulatory provision are met (Baldauf. 2010; Yassi *et al.*, 2013; Holl *et al.,* 2016).

Safety is a team effort and one of the most effective ways to start addressing safety in the workplace is by developing a safety committee (Newman, 2017). A safety and health committee is a committee made up of workers and employer representatives working together to identify and resolve health and safety problems in the workplace. The safety committee is established to be of benefit first and foremost to the employees it represents, but it is also as a safeguard and protector of the company's asset. A safety committee is set up by an organization to create a forum where issues concerning the safety of the organization such as accidents, near misses, corrective actions and opportunities for improvement are discussed. Since it consists of staff from various departments up to and including management level it was anticipated that there would be interest for the betterment of the company to reduce accident. (Uwerevu, 2011).

(Duke, 2012) noted that most safety committee meetings are not really productive and recommendations made are not taken seriously by management. Thus, safety committees don't really effect the needed changes, leading to poor committee performance. A safety committee

should measure its performance to identify opportunities for improvement and continue to do what is working. According to a fact sheet from the Canadian Centre of Occupational Health & Safety (CCOHS), an improved safety performance indicates that a safety committee is effective (Tuohy & Simard, 2011; Manoukian, 2015). The health and safety committee is an advisory committee to ensure a healthy and safe workplace and not as a body responsible for enforcing legislation. The committee recommends actions to management who has the authority to make changes to meet goals and objectives.

In the United States data from 113 companies in Maine over a six-year period was collected and analyzed. Researchers found out that the presence of a safety committee in those companies was associated with a small decrease in time loss claims due to injury. In contrast, in a study of 127 manufacturing firms in Massachusetts, (Boden *et al.*, 1984; Spath, 2010; Milgate *et al*., 2012; Kellerman, 2015) the researchers determined that the presence of a safety committee did not reduce the number of health and safety complaint. The study appeared to indicate that the presence of a safety committee may not be enough and that the key to success with these committees may be in ensuring their effectiveness.

Tuohy & Simard (2011) found in a study of Quebec and Ontario workplaces that Joint Health and Safety Committees with equal number of worker and management representatives had both lower injury rates and demonstrated enhanced problem-solving expertise compared to workplace without these committees. The existence of safety committees is associated with appropriate measures to confront hazard and increase safety.

2. Elements of An Effective Safety Committee

Communication/Information Dissemination

According to Tuohy & Simard, (2011); Bukowski, (2014) and Kellerman, (2015) the flow of information between Safety Committee members and workers needed to be regular and timely. This thus shows staff the organization is improving health and safety by addressing problems, which encourages workers to take an interest in their own health and safety, and that of their work colleagues. Uncommunicative or unsupportive management reduces the effectiveness of committees.

If management disagrees with a recommendation, the response must give the reasons for disagreement. Having an agenda and having goals set ahead of time are of primary importance to a safety committee, according to Geldart & Smith, (2010) and Pratt *et al.*, (2010). They noted that when the safety committee in their company organized a kick-off meeting at the beginning of the year, set the goals for that year and published it in the company's newsletter, everyone got involved and got things done.

Information on potential hazard and actual accident should be available for members of the safety committee. Minutes of safety committee meetings should be distributed to all committee members and various departments. The committee should keep record of each meeting for three years. The information of each meeting should include; meeting date, attendees' names, safety and health issues discussed, recommendations for correcting hazards and reasonable deadlines for management to respond. Feedback meeting with workers affected by the safety committee's decision should be held as this will assure workers of management's commitmentt (Burke et al., 2012; Manoukian, 2015).

Membership Representation and Management Support:

According to Burke *et al*., (2012); Holl *et al.,* (2016); Ikpesu, (2016) and CCOHS, (2018) periodically changing the employee membership of the committee allows the greatest possible number of employees to take an active part in the safety effort of the organization. It also provides the committee with a constant influx of different viewpoint and new ideas, provides a challenge to existing members, prevents them and the committee from becoming stale and preoccupied with routine work.

In his research, Plischke, (2014) found that committees that made a meaningful impact on workplace safety had clear and visible upper management support. This allowed committees to secure funding or support to quickly address a safety hazard. Similarly, according to Wanderhoof, (2012) and Tuohy & Simard, (2011), an effective safety committee will have appropriate senior management representatives, so that decisions can be approved and actioned without needing to refer them for further approval. Management participation in meetings is important for the committee to make realistic decisions and recommendations.

Milgate *et al.,* (2012) reported that the effectiveness of a safety committee depends on the results it achieves, and this in turn depends on action being taken by management to implements the committee's recommendations. Results that include correspondence, briefs, reports, test results, records of employee training and/or hazard documentation should be recorded and kept.

Self-Evaluation:

Kellerman, (2015) noted that a safety committee measures its effectiveness by frequently checking if goals and expectations are being met. According to Geldart & Smith, (2010) and Holls, (2016), follow-up reports assess the status of the action items. Baldauf, (2010) and Bill, (2015) noted that Key Performance indicators (leading and lagging) are to be measured to assess the effectiveness of a safety committee, and to determine what needs to be done to improve the safety culture of an organization.

According to Manoukian, (2015) laging indicators are reactive in nature. They measure the effectiveness of a safety program after the facts. Typical lagging indicators include the number of incidents, injuries, days away from work (DAFW). In contrast, leading indicators are proactive in nature. They consist of safety initiatives or reported activities, with the aim of preventing adverse events before they happen. Hence leading indicators: contribute to:

1) Improving safety through insight and prevention and

2)Showing stakeholders that the organization is taking proactive steps to attain safety excellence.

According to Spath, (2010). Workplace Safety Committee Guide, (2012); Plischke, (2014) and Boden *et al.,* (2015), minutes of meeting is another way to examine safety committee's performance. Minutes should reflect what actions and decisions the group made. Minutes of safety committee meetings keep a track record of safety problems and state what recommendations have been made (CCOHS, 2018).

Member Training

Assessment of the safety committees in over 20 companies was carried out by Tuohy & Simard, (2011), and their findings showed that there was a greater decreases in injury rates in companies whose committee members received training. They stressed the importance of training, stating that members of a safety committee will not be able to conduct their task effectively if not trained. Burke (2012) and Wanderhoof, (2012) noted that all committee members are needed to be trained on the task and procedures of the safety committee, on hazard identification, accident investigation, raising and solving health and safety issues. Other elements of effective safety committee are structure/composition of the committee, management of the committee, frequency of meetings, agenda and minutes of meeting, location and timing of meetings (Boden *et al.*, 1984; Pratt, 2010; Bukowski, 2014; Silburn, 2015; Greeley, 2016; Iteire, 2019, Workplace Safety Committee Guide, 2012)

3. Methods

It is important that the Safety Committee should not only be set up in the industries, but must be effective in applying safety policies. This study was therefore designed to evaluate the effectiveness of the Health and Safety committees in the selected oil/ gas, construction, and flour mill companies in Delta State.

A questionnaire was use to gather data in this research. 34 questionnaires were distributed to company A, B, C but retrieved 26; 36 questionnaires were distributed to company D, E, F and 33 were retrieved; while 34 were sent to company G, H, I. The 34 were retrieved from company G. and H but no questionnaires were retrieved from company I. Data collected was evaluated statistically using a safety

committee audit tool coined from National Health and Safety Division to ascertain percentage compliance. To demonstrate an acceptable level of compliance a bench mark score of 100% should be achieved. The mean score gotten was then compared with the score rating below to know the level of effectiveness of the safety committees in the selected companies.

Table 1.
Traffic Light System for Safety Committee Audit

80 - 100%	**Compliant - repeat self-audit on annual basis**
66 - 79%	**Good - Repeat self-audit 6 monthly**
26 - 65%	**Acceptable - Repeat self-audit 3 monthly**
0 - 25%	**Critical -immediate action by Chairperson of committee - Repeat audit montly**

Chi-Square test was used to check if a significant difference exists between the observed and the expected level of effectiveness.

H_0: There is no significant difference between the observed and the expected level of effectiveness

H_1: There is a significant difference between the observed and the expected level of effectiveness

4. Results

Table 2: *Percentage Rating of Safety Committee Elements for the Selected Companies in Delta State*

S/N	Element	Expect	Observed								
			Oil/gas			Construction			Flour mill		
			A	B	C	D	E	F	G	H	I
1	Composition	100	80	72	80	73	79	82	90	90	0
2	Membership Representation	100	85	95	90	56	64	55	85	80	0
3	Self- Evaluation	100	78	56	58	31	44	35	90	63	0
4	Management of committee	100	72	88	60	76	79	78	80	80	0
5	Training	100	63	40	53	67	62	41	75	60	0
6	Communication	100	66	52	45	39	45	40	65	73	0

Table 2 shows that the safety committees in the selected companies were more compliant in their composition and membership representation but were least compliant in communication and training of their members.

Table 3: *Safety Committee Effectiveness Average for the Selected Companies in Delta State*

	Oil/gas			Construction			Flour mill		
COMPANY	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
OBSERVED	74	67	64	57	62	55	81	74	0
EXPECTED	100	100	100	100	100	100	100	100	100

The table above shows that the safety committee in company G has the highest percentage rating, while that company F has the lowest rating.

Figure 1
Graphical Presentation of Safety Committee Effectiveness

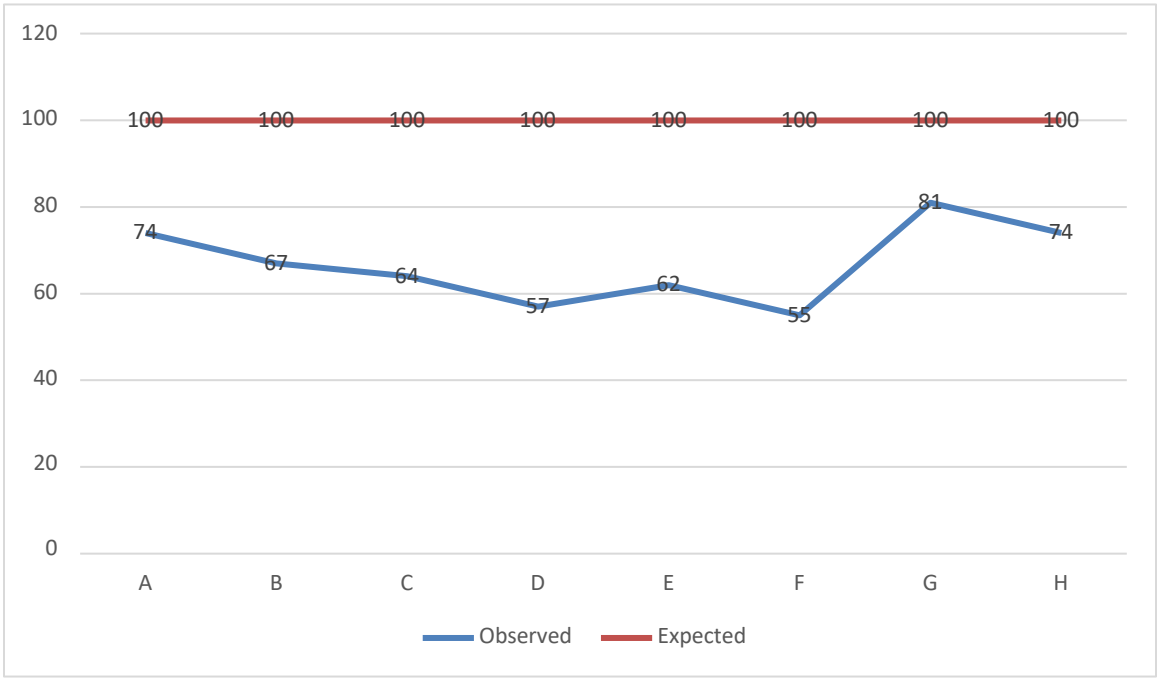

Table 4. *Chi-Square Calculations*

ompany	A	B	C	D	E	F	G	H	
Observed (O_i)	.740	.672	.553	.572	.622	.552	.808	.743	
xpected (E_i)	.000	.000	.000	.000	.000	.000	.000	.000	.00

$$xx^2 = \sum_{i=1}^{a} \frac{(Oi - Ei)^2}{Ei}$$

$$= \frac{(0.740-1)^2}{1} + \frac{(0.672-1)^2}{1} + \frac{(0.553-1)^2}{1} + \frac{(0.572-1)^2}{1} + \frac{(0.622-1)^2}{1} + \frac{(0.552-1)^2}{1} + \frac{(0.808-1)^2}{1} + \frac{(0.743-1)^2}{1}$$

$$= 0.0676+0.1076+0.1998+0.1832+0.1429+0.2285+0.0369+0.0660 = 1.03$$

$xx_{0.025,\ 7} = 1.69$ $xx_{0.975,7} = 16.0$

5. Discussion of Results

The results obtained from the study showed that the selected oil/gas, construction, and flour mill companies in Delta state have safety committees except Company I.

Six elements were used to assess the effectiveness of the safety committees in each selected company, which was compared to different Safety body standards. The overall performance of each company's safety committee was determined with the aid of a safety committee audit tool and the assessment of their Key performance Indicators, in which Company G was ranked the most effective with an average of 81%, while Company F the least effective with average of 55%.

Composition/structure of the committees

In Company A and B, the Managing Director is the Chairman of the Central Safety Committee, while in Company C, the General Manager, Process is the Chairman of the Committee. This is in line with what is recommended by OSH, 1996 Regulation, CCOHS, (2018) which noted that an employer or his authorized manager can be the chairman of the safety committee.

Still on the composition of the committee, Company A has four subcommittees along with a central safety committee, Company B has two subcommittees along with their management safety committee but this could not be determined in Company C as such information was withheld. This, thus ensured more workers involvement and participation in safety in Companies A and B. This is in agreement with the findings of Tuohy & Simard, (2011).

The lagging issues in Companies A and B is that they have more employer-selected members than employee-elected members. This is against the Oregon OSHA guide, (2014) requirements.

Company F had an equal number of management and employee representatives in accordance with Karl, (1997) and CCOHS, (2018) but company D and company E had fewer member representatives.

Membership Representation

In the selected oil/gas companies assessed, the safety committees present in Companies A and B have representatives from senior management, departmental heads, safety personnel and administrative support. The committees consist of members from various departments. The KPI observed in respect to this showed that one out of the two recommendations made were implemented by management within the last five months at Companies A and B. The safety committees in company B had members from various department including a Medical officer.

The KPI observed in respect to this showed that 81 recommendations have been implemented within the last two years. This is in agreement with Morse *et al.*, (2012) who noted that recommendations made by any safety committee with appropriate management representation will be easily implemented.

The safety committee members in Company B serve a maximum of two years. This is acceptable when compared with standards on safety committee. On the contrary, members of safety committee in Company A served for more than two or three years. The information obtained from this research shows that the term of service for members of the committee in company A is position based, meaning that members continue to serve until their job title is changed or on retirement. The safety committee in Company C do not have members from various department but members serve on the committee only for one year. It was only the safety committee in Company B that had a medical representative in accordance with Karl, (1997) recommendations. It was also noted that all the safety committees have an appropriate number of committee members. This made company B more compliant with standards and more effective.

In the selected flour mill companies assessed, company G had a better membership representation. The members of the committee consist of a senior manager/chairperson of committees, departmental heads, safety representatives. Also, committee members are allowed to serve a minimum of two years. This ensured a good number of employees to take an active part in the society effort. This is in agreement with South Australia Work Health and Safety Regulation (2012).

Management of the Committee

Company B was found to be more effective in the management of their safety committee. This was due to the fact that the committees have established terms of reference which includes; the objectives of the committee, roles and responsibilities, membership, and frequency of meetings, and their terms of reference were constantly being reviewed every year. This yearly review of reference ensured that meetings were up to date, more than half of the objectives were achieved, and resources to carry out their responsibilities were sufficiently provided. This is in agreement with Geldart & Smith, (2010) who noted that any safety committee with established procedure for self-monitoring would meet their targeted objectives. Another reason is that the safety committee has a quorum consisting of the chairman, secretary, and five other workers. This is in accordance with (Oregon OSHA guide, 2014) on safety committee.

The safety committee in three companies meet on a quarterly basis. Minutes of meetings observed showed that the meetings of the safety committee in companies A and C spend more than one hour, but that of company B lasted mostly for one hour.

KPI observed shows that the safety committee in Company B has conducted a total number of thirty-six (36) inspections, two (2) management walkabouts, and twelve (12) committee meetings in five (5) months. This shows its effectiveness. Also, the KPI observed in Company A showed that the number of inspections carried out increased from 12 to 17, the number of management walkthrough increased from 3 to 4 in a period of two years.

The table 1 shows that Companies D, E & F have poor committee management with company D as 31%, company E 35%, Company F 44%. This is in agreement with Hayes *et al.*, (2016) who noted from their findings that most safety committee members lacked understanding of the roles and responsibilities of the safety committee and thus reduced its effectiveness.

Performance/self-evaluation

The safety committee in Company G had the highest percentage average. This was due to the safety committee regularly reviewing records on work-related injury/illness. Judging from their key performance indicators, there have been a significant reduction in lost time injuries and First Aid cases. This is in agreement with Bryce *et al*., (2010) research findings. Minutes of meetings examined also showed that most recommendations made have been implemented

by management. This is in agreement with CCOHS, (2018) and Manoukian, (2015) anticipated outcomes. The key performance indicators also show that the management has implemented more recommendation within the last two years. While assessing a few minutes of meetings of Company G, it was noted that the safety committee kept track on things that needed management intervention, and it was only after such recommendations had been actioned it was closed out. This observation is in agreement with Boden *et al.*, (1984) who noted that minutes of meetings helps to show trends and reveal problems requiring more investigation, the training of a new committee members, or the determination of safety training topics.

Training

In company A, only but a few members of the safety committee had been trained in safety related courses, while in company B, only the safety representative had received training. This was prior to the inception of the safety committee. Information from the questionnaires retrieved showed that members of the safety committee in Company C had been trained on hazard identification, workplace inspection and accident investigation. Since the Key Performance Indicators for Company C were not assessed, this study could not agree or disagree with Burke et al., (2012) who noted in his findings that training of committee members resulted in the significant reduction of accidents.

The training matrix from Company D indicates the almost all safety committee members have received safety related training. While going through the HSE Records of company E, only a few members had been trained in safety related topics. It was observed that the number of safety committee meetings and the number of emergency drill had decreased drastically within the period of 5 years. This is in agreement with Hayes *et al.*, (1998) who noted that most safety committee members lacked awareness of safety related issues and stressed the need for educating and training of safety committee members. In company G and H, only the safety officers had received safety training.

Communication

From the result, it can be seen that the safety committees in all the companies evaluated, lack good communication systems with both workers and management. This is said because workers in company A only made use of minutes of meeting and memorandum to communicate ideas and recommendations to management and vice versa. From the KPI observed, only three staff feedback/input was achieved and there was just one learning from incidents. The number of HSE awareness campaign reduced drastically from 266 to 15 in a two (2) year period.

The KPI observed for Company B showed that there is zero staff/feedback input and only one learning from incidents but there were 61 HSE awareness campaigns.

Information from the questionnaires completed showed that the safety committee and management of Company D only communicates through minutes of meetings, the committee only communicates to workers through notice boards and workers do not have access to the committee's activities. Data collected also revealed that workers in Company E only communicate to the safety committee through the suggestion box. This method is said to be ineffective since members of the committee hardly visit the suggestion box, thus reduces workers involvement in safety. This is in agreement with Dey and Malik, (2017) who noted that an uncommunicative management reduces the effectiveness of a safety committee.

Discussion of Chi-Square test

The Chi-Square Test is used to evaluate differences between experimental or observed data and expected or hypothetical data. As a "goodness of fit" test, it tells us how well a set of observations fits the outcome predicted by the hypothesis being tested.

Since chi-square cannot be calculated using percentages, the percentage effectiveness was converted to actual figures by dividing by 100. The expected data was then 100% that is 1 when converted to actual numbers. The X^2 calculated was found to be 1.03, while the X^2 tabulated ranges were between 1.69 and 16.0 as lower and upper region respectively.

Since X^2 calculated falls in the lower critical region, we rejected the null hypothesis, and therefore conclude that there is a significant difference between the observed and expected level of effectiveness at 5% level of significance. This suggests that the safety committees in the companies evaluated need to address the areas where they are lagging and make necessary changes in order to increase the level of effectiveness.

6. Conclusions

Despite various limitations, this project work was able to achieve its aim as the level of safety committee application and effectiveness in the selected oil/gas, construction and flour mill companies were determined. The effectiveness of the safety committees on a percentage level in company A was 74%. 67% in company B. 64% in company C. 57% in company D. 62% in company E. 55% in company F. 81% in company G, and 74% in company H. Using the Traffic Light System for the Safety Committee Audit Tool the level of safety committee in effectiveness the selected companies is acceptable.

7. Recommendations

From the various observations made, the following are recommended;

1. It is recommended that Employee participation on the Safety Committee is rotated as this raises awareness and promotes engagement by including a wider group of people.
2. Each year the safety committee's progress should be reviewed in order to evaluate the group's success in helping the organization to meet its safety goals and objectives.
3. It is recommended that safety committees develop and maintain an effective system of communication with employees, keeping them informed of the committee's activities.

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Worker Complacency Towards Work Method Statements in the Australian Construction Industry

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Abstract

Work Method Statements (WMS) are a key strategy relied upon in the Construction industry to ensure that safe work is conducted, and safe work practices are followed. However, an increase in a number of observed behaviours indicate that employee complacency is a major issue regarding the adherence of WMS practices for this industry. Employee's beliefs about complacency towards WMS was therefore explored with employees indicating that repetition/routine, lack of interest, boredom, poor communication and personality clashes/conflict were the main factors that drive complacency. Employees identified that complacency was more prevalent at the end of the working week or shift cycle for some employee groups, however this was not reflected across all job divisions. Results also identified that a high percentage of employees supported positive communication in the form of encouragement, humour, personal discussions and job-related issues to reduce this workplace complacency. Suggestions for stopping complacency also included encouraging increased interactions between workers and management in order to guide and support employees, as well as identifying which tasks contributed to increased levels of complacency. Employees identified that increased site visits, having positive interactions and discussions as well as implementing group reviews would see a demonstrated greater sense of active involvement in workplace safety in order to reduce complacency.

Keywords: Complacency. Safety Culture. Work Method Statements. Positive Interactions.

1. Introduction

In Australia the Construction Industry remains one of the top three most dangerous industries just behind Transport, postal and warehousing (38 fatalities), followed closely by Agriculture, forestry and fishing (37 fatalities) and the Construction industry had 24 fatalities in 2018 (Safe Work Australia, 2020). Over the five-year period from 2014 to 2018, there were 156 worker fatalities in the Construction industry in Australia. These are not attributed to industry size but to a disproportionately high fatality rate for this industry with falls from height being the main mechanism of fatality. The construction industry also averages 12,652 serious injury claims each year (2001-2016) (Safe Work Australia, 2018). An investigation into issues being faced by the Construction Industry in an attempt to reduce these numbers (Safe Work Australia, 2012) has pointed towards a culture of safety becoming a mere paper-based exercise and made seven recommendations for the industry related to work safety culture, consultation and collaboration. The report emphasised the importance of a collaborative approach to resolving safety issues on construction sites (Safe Work Australia, 2012).

There has been an increase in the number of employees working on a commercial construction project demonstrating observable behaviours that indicate employee complacency regarding the following of the information contained in all Work Method Statements (WMS) and/or any organisational policies and procedures that relate to the work method statements. Injury reports also confirmed and suggested that causes of some injuries were due to employees not following the work method statement provided.

2. Worker Complacency

Complacency is a natural function and is defined by the Merriam-Webster Dictionary (2018) as self-satisfaction, especially when accompanied by unawareness of actual dangers or deficiencies, and has numerous driving factors. Poisseroux (2010) highlights that complacency in the workplace often occurs

when employees become accustomed to completing tasks in a defined manner as it cultivates a culture where employees become oblivious to the hazards that may be encountered during the task.

Whilst Guo, Yiu and González (2016) suggest that level of experience, knowledge and skills will contribute to an accident occurring in the construction industry, Zin and Ismail (2012) suggest that the main contributor to workplace accidents occurring is attitude and behaviour. Hale et al. (2012) also point out that safety occurrences can be associated with motivation, morale, compliance, complacency, overconfidence and perception of risk. Individual workers have differences in perceived levels of risk and complacency which will vary depending on the duration between changes in work environments, the allocation of new tasks, the level of interest in new tasks, the use of new equipment and personality clashes with team members (Hayes, McDermott & Lingard, 2015). It has recently been stated that most risk analysis methods in the construction industry lack a theoretical background and therefore the analysis of safety risk has traditionally had limited measurable factors, making the assessment and understanding of why accidents occur now needing to be more practical in relation to understanding risk generation and mitigation (Choe & Leite, 2020).

Multiple factors drive complacency and in attempting to understand the behavioural traits that drive complacency, it is noted that several key factors increased the level of complacency experienced by employees, including proceduralised or repetitious tasks that led to disinterested or bored employees (Hayes, McDermott & Lingard, 2015). Other contributing factors comprise poor communication, conflict of ideas, personality clashes that cause conflict, as well as issues being poorly discussed, poorly communicated, poorly instructed, no positive feedback systems in place as well as directions or instructions not being understood by all employees on the site (Krishnamurthy, 2015).

Later research into safety complacency by Årstad and Aven (2017) identify that complacency should be looked at as an issue which not only *affects* the system, but one which *reflects* what is happening in the wider organisational system. Their examination of complexity in major safety events points towards management over confidence and conclude that "the notion of complacency is used to express concerns about a systemic issue and reveals concerns about relating to complexity in practice" (Årstad & Aven, 2017, p. 121). Complacency around following workplace safety processes and procedures can therefore point towards dysfunctional current practices.

3. Work Method Statements

A Work Method Statement (WMS) is described by the Office of the Federal Safety Commissioner (2018) as a document that identifies all hazards that may be found in a workplace and assesses the risk these hazards may present as well as identifying the control measures that must be implemented. Furthermore, Work Health and Safety Regulations in Queensland, Australia mandate that a Person Conducting Business or Undertaking (PCBU) in the construction industry must develop and publish a WMS which will (a) identify the work that is high-risk construction work; (b) state hazards relating to the high-risk construction work and risks to health and safety associated with those hazards; (c) describe the measures to be implemented to control the risks; and (d) describe how the control measures are to be implemented, monitored and reviewed.

A WMS is similar to a Job Safety Analysis (JSA), as they both guide safe work practices for all workers, by breaking down all work activities into a series of steps to recognise the hazards that may be encountered and identify the risk controls that may be introduced into each step to eliminate the risk or reduce the risk to an acceptable level (Sanchez, Pelaez & Alis, 2017). Saunders et al. (2016) suggest that the organisation must include reference to the WMS in their risk management practices, to ensure that all the hazards for a specific work function have been identified and documented, in consultation

with all employees and contractors performing the tasks. Recent research by Arstad and Aven (2017) has concluded that 'the notion of complacency is used to express concerns about a systemic issue and reveals concerns relating to complexity in practice' (p. 121) as well as it leading to major accidents.

4. The Construction Project

This research was conducted in an Australian commercial construction setting. The construction project contained numerous work functions in cross-harbour coordination, purchasing and expediting, inventory management, transport and logistics, materials management, IT systems management and interaction with the client. Responsibilities found in the project site encompassed all mainland facilities which included multiple laydown yards, transport and logistics to include warehouses, truck marshalling yards and marine loading facilities. Furthermore, the commercial construction company embedded the legislative principles of all industrial, safety and environment legislation, enacted by the Commonwealth and State jurisdictions, as well as ensured that organisational environmental, safety and health requirements and all relevant policies and procedures of the client were implemented at the project site (Saunders et al., 2016).

5. Methodology

The principal methodology employed for this research was ethnography, to identify complacency and determine if a worker had been affected by complacency, as well as having an outcome of providing suggestions on how to identify complacency in the workplace. The rationale for undertaking an ethnographic approach was to subjectively identify the reason employees are experiencing feelings of complacency into following the work method statement approved by the construction company (Albert, Hallowell & Kleiner, 2013).

As there are numerous different job titles throughout the construction process it was decided to collect data via job divisions. These job divisions include operators and truck drivers, cranes rigging and doggers, warehousing and stores, and others consisting of labourers, peggies and tradesman. These job divisions were chosen due to the fact that the nature of the work would have them signing on to similar work method statements (in most cases). The way in which data was collected was a sensitive issue due to the stage of the project. A questionnaire was developed in order to survey employees with 140 participants completing the questionnaire. These participants worked in the operational areas of transportation (truck drivers and operators n=42), warehousing (store-persons, forklift drivers n= 30), crane operators (riggers, doggman n= 45), labourers (veggies, trades-persons, others n=23), as these operational areas had agreed to similar work method statements.

Participants were given the definition of complacency and asked a series of questions covering two main areas, one being their knowledge, input and suggestions for WMS and the second area being about complacency. Questions asked a serious of yes or no response questions to things like Do you input to WMS? Do you think you or others are affected by complacency? Other questions were open ended such as If you could suggest something to stop complacency in the workplace what would it be?

6. Results

Results indicated that all employees had a wide understanding of complacency, with 87% admitting they had been affected by complacency or knew somebody who is or has been affected by complacency as shown in Figure 1.

Figure 1

Percentage of Employees Affected by Complacency by Operational Area

Due to the diverse nature of the project and with employees frequenting multiple locations, the survey also found that 61% of employees had worked in multiple locations within the project and 25% of these acknowledged the same level of complacency was experienced in all locations. However, 78% indicated that the complacency level varied between locations with a higher percentage of reporting a growing increase in levels of complacency experienced.

6.1 Complacency Drivers

Over all employees identified that repetition/routine (83 responses), lack of interest and boredom (38 responses) and poor communication/personality clashes/conflict (22 responses) as the three highest factors that drive complacency. Several other factors were identified in relation to why complacency was occurring in relation to the SWM as shown in Figure 2. Repetition was acknowledged as being the biggest contributor for all workers, followed by boredom, morale and to a lesser extent issues such as communication, distraction and external issues were reported.

Figure 2

Complacency Driving Factors

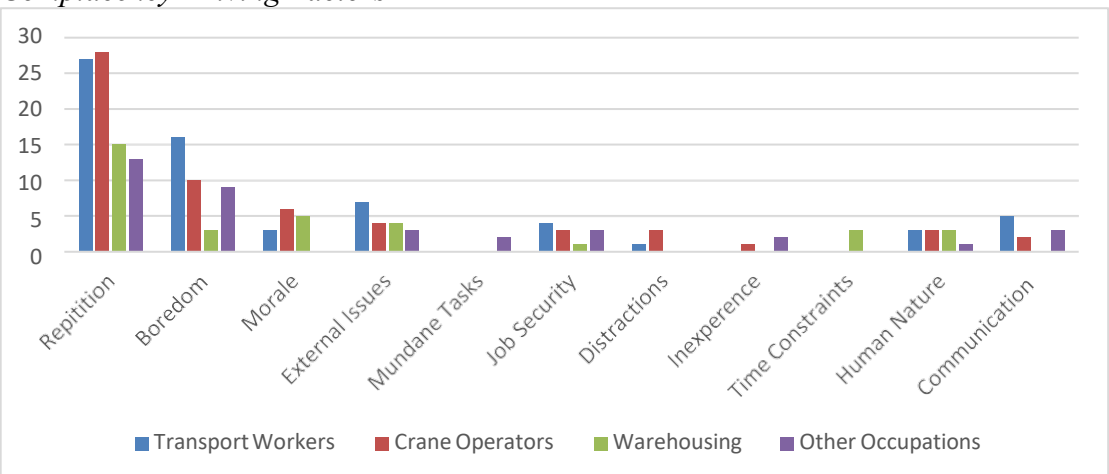
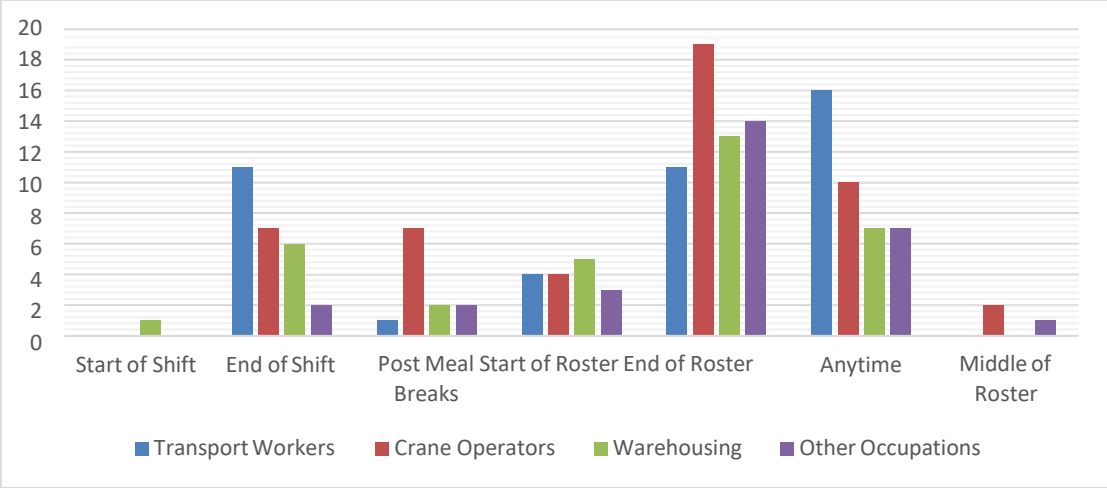


Figure 3

Time Periods Prevalent to Complacency Issues



It is recognised that time and events may impact on vigilance and concentration (Beattie, Fakehy & Woodman, 2014) and that employee complacency is not limited to a specific point in time or duration. Employees were asked to identify if they noticed any specific times where they perceived a greater risk of experiencing complacency, with a high percentage of employees identifying more than one time-period over the shift and during the roster. Two prevalent time periods of the work cycle as shown in Figure 3 above were found to be important with end of roster being a particular time when complacency becomes apparent for some occupations whilst the notion of 'anytime' also appeared relevant, especially for transport workers. Transport workers generally appeared to be the occupation who had the highest level of complacency across multiple time frames.

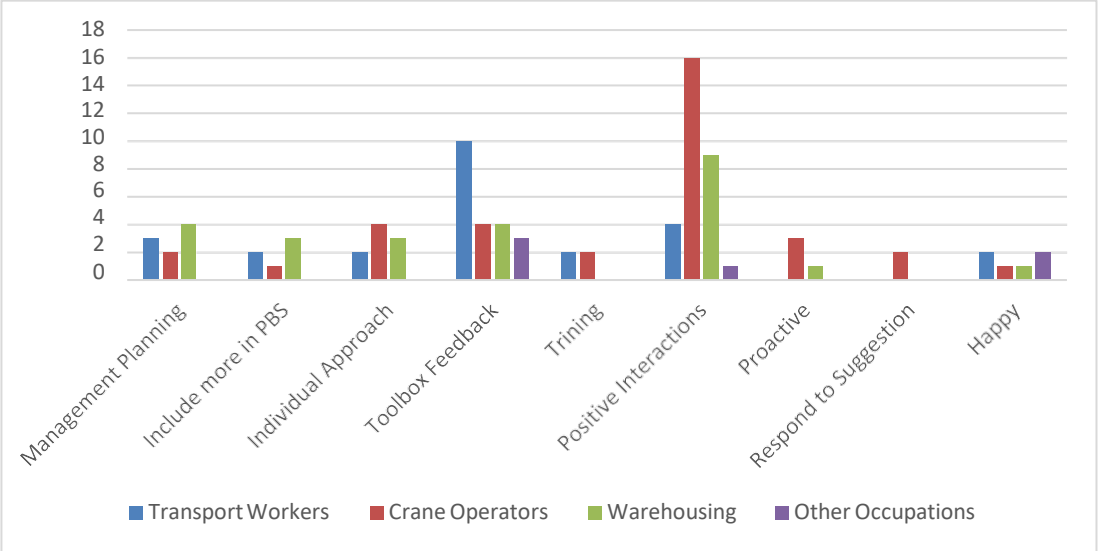
Even though it was acknowledged by the employees that they and the management team on the construction 33reported deficiencies in the level of support provided by the management team. It was also noted that inadequate supervision, as well as the managers not encouraging or recognising the work completed by the employees in line with these goals leads to an environment of low morale, as employees lose interest in the project and the willingness to complete a task in the timeframe set (Dansoh, Frimpong & Oteng, 2017). This implies that while the management team is focused on negotiation with all stakeholders to resolve claims, prevent disputes (San Cristóbal, 2015), the relationship between them and the employees is not harmonious.

6.2 Environment Safety and Health (ESH) Involvement

When discussing whether or not ESH involvement can help employees identify complacency in the workforce a clear project overall consensus of more 'positive interaction' which suggests the need for more positive on-site involvement resulting in flexibility, discussions, presence (not just when management is around). However, across the board the numbers do not greatly vary, as shown in Figure 4 Suggestions on how ESH can help identify complacency.

Figure 4

Suggestions for ESH Assistance to Identify Complacency



However, the suggestion for more 'positive interaction' can be incorporated into not only positive interaction in the field but in the second suggestion of more toolbox/feedback and communication. It should also be noted that individuals had trouble in coming up with suggestions for this issue. Conversely some employees did show an interest in training as mentioned above and the possibility of having toolbox meetings earlier in the week to promote safety early instead of later/mid-week.

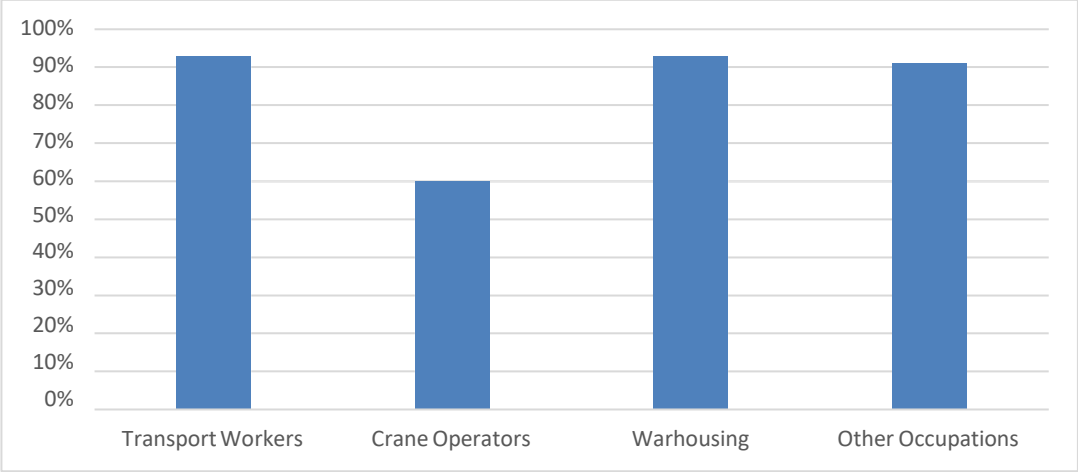
The most identified methods of stopping complacency were positive communication (74%) in the form of encouragement, humour, personal discussions (caring) and job-related issues. Employees identified numerous possible times that complacency may become more prevalent with the end of the week (37%) being the most common throughout the project but not necessarily across all job divisions. When looking at data collected across the project in regard to suggestions to stopping complacency and ESH involvement in helping employees identify complacency, there were many suggestions, all of which would aid the project in complying with Queensland Workplace Health and Safety Act and Regulations.

6.3 Employee Input into WMS

Employees recognised that there are many benefits of having WMS other than just to be law abiding. Many of these benefits were discussed and pointed out when talking to employees in regard to why they have WMS. Employees identified that WMS were beneficial to them as a hazard identification tool and a point of reference for tasks, it was a positive tool in allowing everyone to work in a similar/same fashion safely. When looking at employees' beliefs of whether or not they have input into their WMS 84% of employees believed that they have positive input as shown in Figure 5.

Figure 5

Employee Input to WMS



However, when looking at job division only 60% of Crane Operators (Rigging/Cranes/Doggman) felt that they have input, in effect leaving 40% feeling like they do not have positive input.

Employees were also asked if they are given enough time to make changes and review their relevant WMS every month. 79% of agreed that they were given enough time. However, on further breakdown via job divisions only 64% of 'Operators/Trucks' agreed that they were given enough time to change and review them as shown in Figure 6. It should be noted a further breakdown shows that 96% of employees hired as truck drivers are happy with their input into their WMS so the overarching response of employees hired as operators is reducing the percentage of 'yes' responses when asked if given enough time to change/review WMS.

Figure 6

Sufficient WMS Review Period by Operational Area

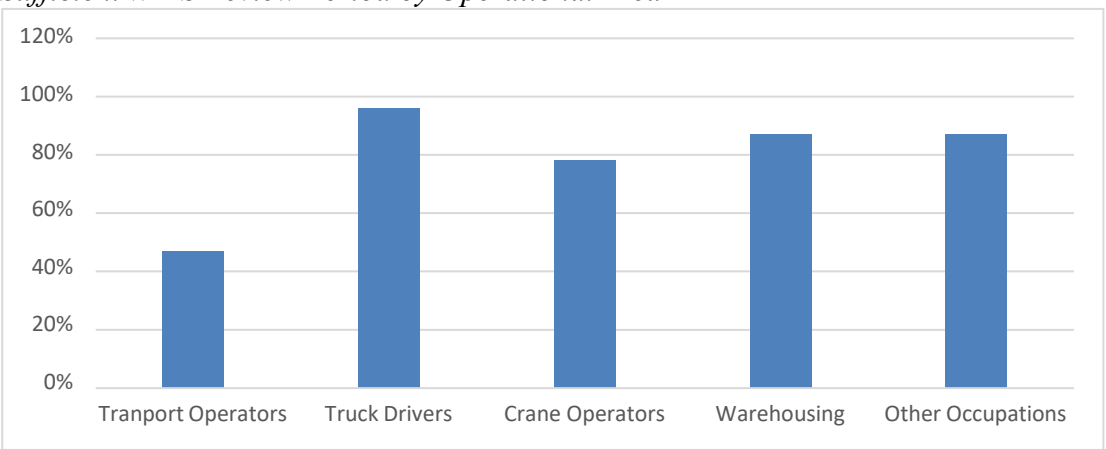
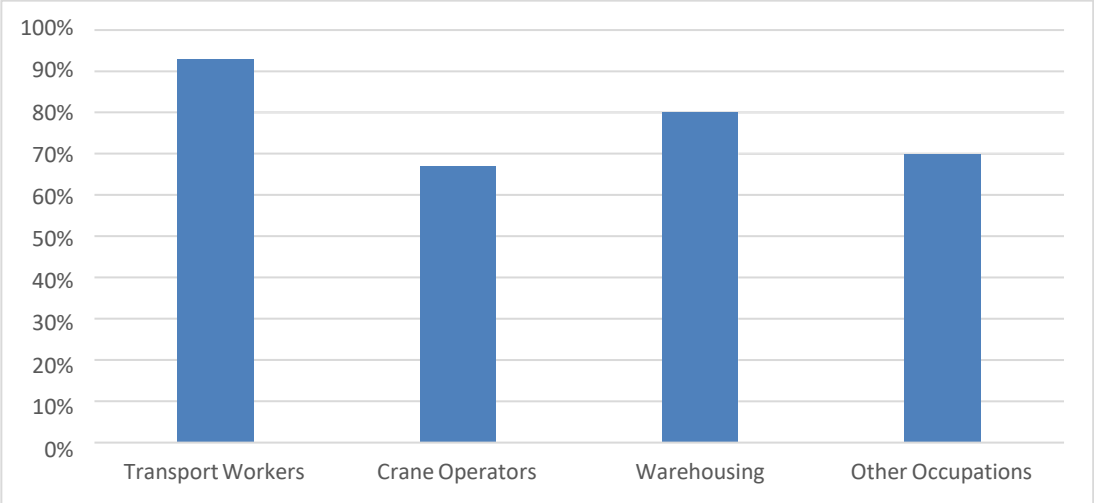


Figure 7

Is the WMS Explained



Similar results can be seen when looking at employee beliefs about explaining WMS. The project overall showed 77% were happy with any explanations they received in regard to WMS and a breakdown via belief levels and job divisions shows a possible problem with job division 'Riggers/Cranes/Doggers'. This can be seen in Figure 7 above.

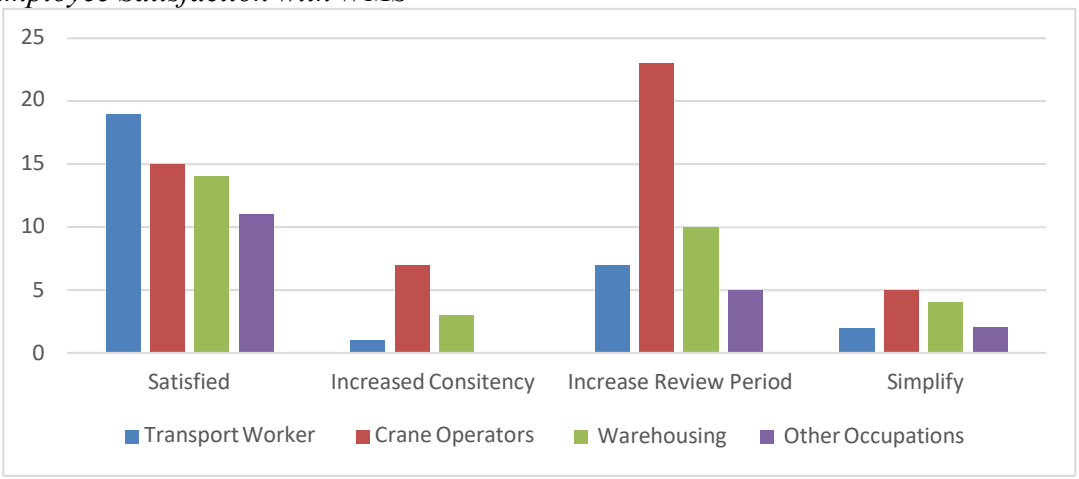
When looking at the statistics for the project in regard to employees ticking and flicking the WMS every month, 83% of employees felt that 'yes' people do tick and flick the WMS. Numerous employees identified that it is an individual factor, there are time pressures and it is a repetitive task. Employees came from a very diverse range of different education levels, life experiences, exposure to industry and age. These determinants of health along with many other factors can influence individuals greatly in regard to job interest or job knowledge. The ability to acquire and implement new knowledge, comprehension and reading levels can vary greatly among individuals and this can also influence other factors; such as if reading and comprehension is hard so too is one's ability to understand WMS and this can decrease job interest, job knowledge or ability to acquire and implement knew knowledge.

6.4 Employee Satisfaction with WMS

Employee suggestions for WMS are quite positive, showing 46% of employees are satisfied with their current WMS and the suggestion. With the most weighing, this is quite positive as it shows employees want to be more involved. Data collected shows the top suggestion was for 'More positive employees input for relevance and practicality, open group discussion with more time to review'; Figure 8 shows the breakdown of suggestions via job division and overall percentages for suggestions.

Figure 8

Employee Satisfaction with WMS

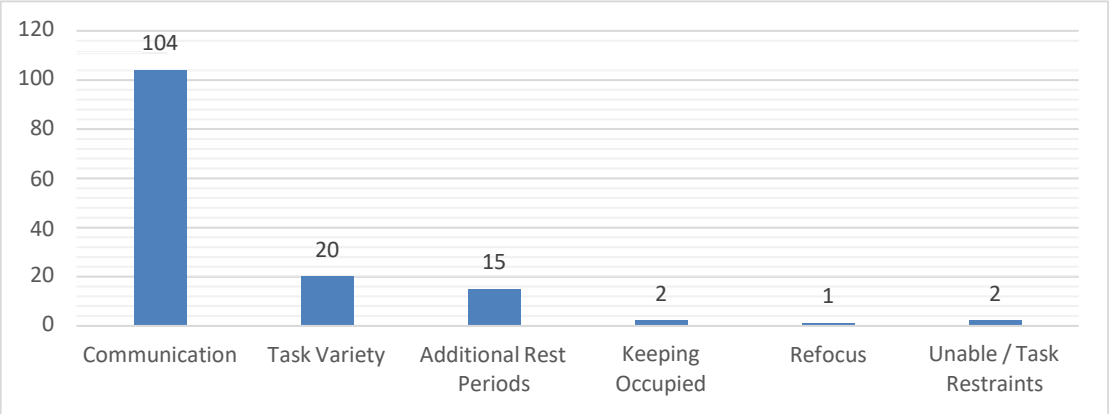


7. Identified Complacency Solution Strategies

Employees were surveyed on what strategies they felt would resolve the issues of complacency and identified effective communication an essential solution strategy to eliminate complacency in the site (Sutherland & Wordley, 2017). Ross (2015) also links positive communication with employee engagement and agrees with the employees surveyed that this may include conversations about work-related activities, encouragement and positive reinforcement, while other conversations could be light-hearted and on personal matters. Employees also pointed out other solution strategies included varying the tasks assigned to them and introducing additional rest periods for mundane and repetitious tasks as shown in Figure 9.

Figure 9

Solution Strategies Suggested by Employees

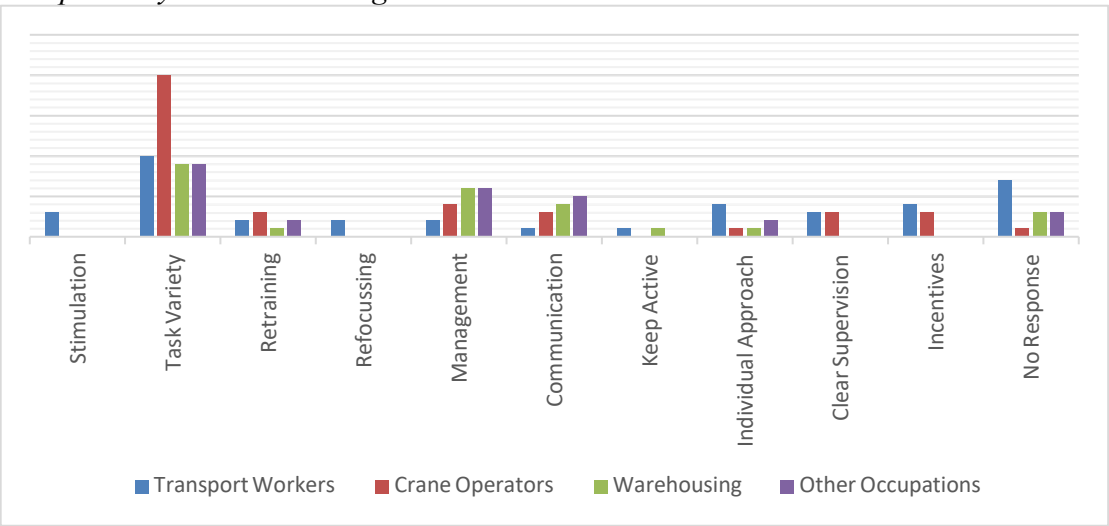


Whilst solution strategies are designed to identify and change workplace behaviours, patterns of inadequate training, poor communication, task variety and job rotation, as well as limited supervision, have been observed (Hyten & Ludwig, 2017). Although most of the employees surveyed presented a wide range of ideas and suggestions to eliminate complacency at the project, a large percentage focused of task variety and job rotation

as the most appropriate strategy, as this would both reduce complacency and optimise the performance of each employee (Salim & Viswanadham, 2017) as shown in Figure 10.

Figure 10

Complacency Solution Strategies

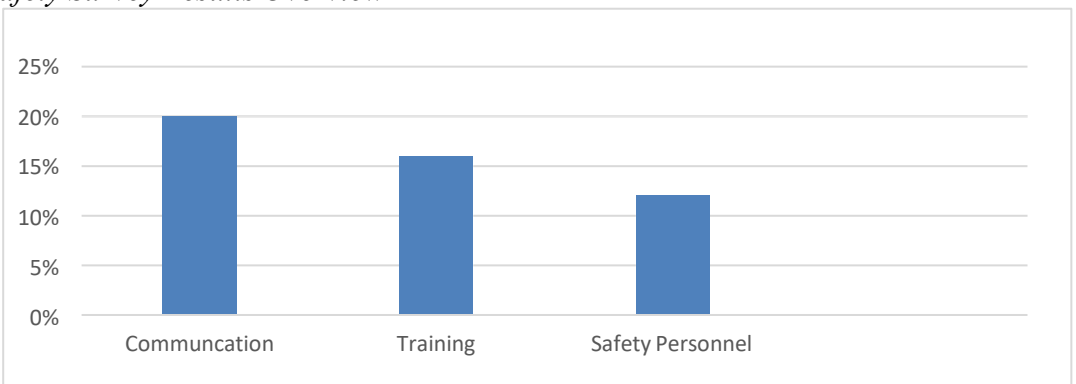


Workplace training was also discussed as a solution strategy because employees in the construction industry appear to have limited skills to complete increasingly complex tasks (Detsimas et al., 2016). Although employees suggested that any training program developed and introduced should not be limited to the classroom, videos and other visual aids provide the employee with a visual representation of the information provided so that it is easier to understand (Shabiralyani et al., 2015). However, employees preferred tactile learning methods, which enables small and large teams to collaborate by applying their fine motor skills to handle materials while learning new or difficult work (Ihsan & Diem, 2016).

Employees were also asked 'what would you change to enhance the Project's safety program?' Results show that employees' top three ways to enhance the safety programme were communication, safety staff and training based as shown in Figure 11.

Figure 11

Safety Survey Results Overview



8. Discussion

The majority of participants surveyed reported being affected by complacency and had experienced it across multiple construction work site locations and construction occupations. Employees identified that repetition/routine, lack of interest and boredom and poor communication / personality clashes / conflict as the three highest factors that drove complacency. The time period where complacency towards WMS was most prevalent was identified as the end of roster. This would make sense if most workers were keen to get home from work rather than completing work procedures and processes.

Generally, the employees identified that WMS were beneficial to them as a hazard identification tool and a point of reference for tasks as well as being a positive tool in allowing everyone to work in a similar/same fashion safely. The majority of employees felt that they had some form of positive input into their WMS. Overall results showed that employees were mostly happy with any explanations they received in regard to WMS but felt that the process was a tick and flick exercise with numerous employees identifying that this might be due to individual factors, time pressures and the repetitive nature of the task.

Employees reported being satisfied with their current WMS but wanted to be more involved and have a more positive input to WMS to make them more relevant and practical as well as wanting to open up group discussions and have more time to review WMS.

Employees highlighted the desire for more positive interactions in respect of the use of WMS with a view to more discussion and flexibility with an increase in presence. Increasing feedback and communication across sites would also increase employees' awareness of changes, incidents and lessons learnt and aid in general compliance. The allocation of specific time for reviewing WMS with a suggested once every two months being sufficient in regard to group/team reviews as WMS were not changing every month. A whole group review lasting or scheduled less than one hour was proposed.

Procedures for implementing changes to WMS that result in more positive communication and contact between relevant parties (employees/ supervision/ ES&H) when implementing changes were seen as important. This would be required to eliminate the possibility of ES&H changes not being identified by employees (by the tick and flick phenomenon as identified above) and to allow employees more of an input into the discussions around WMS. Changing training and toolbox meetings to be more tactile on job training (not just classroom based) was seen as beneficial in keeping employees interested and engaged. Having toolbox discussion early in week was seen as beneficial to encourage people to think about safety earlier in the week.

9. Conclusions

Complacency is a multi-faceted feeling that can be driven by numerous factors. Employees generally identify the common driving factor, of repetition and routine, as a major contributing factor to their complacency. Employees indicated that they would actually like more active involvement in the forms of more site visits, more positive interactions and discussions, and the possibility of implementing wider group reviews. Several suggestions were offered to reduce the continuing 'tick and flick' phenomenon in regard to WMS at construction sites.

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Workplace Human Factors Affecting the Commercial Fishing Industry: A Review of International and National Studies

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Abstract

The commercial fishing industry is a major component of global food supply, with a significant number of people directly employed in the commercial fishing industry. These people routinely work in an environment that is inhospitable to humans, whilst dealing with physical and psychological stressors. Workplace human factors in the commercial fishing industry are widely regarded as not ideal. A review of published literature was conducted to explore commonly identified workplace factors experienced by commercial fishermen and recommendations have been made on ways to improve workplace human factors in the commercial fishing industry.

Key words: Commercial, Fishing, Industry, Workplace Human factors, Ergonomics.

1. Introduction

The global fishing industry employs roughly 35 million people working on 4.5 million fishing vessels (Lucas et al., 2014). The majority (97%) of this workforce are employed in developing countries (Lucas et al., 2014). In Australia 17,000 people were estimated to be employed in fishing and aquaculture from 2017-2018 (Steven et al., 2020). Fishing is critical to much of the world's population, providing a significant source of animal protein to approximately 2 billion people (Lucas et al., 2014). Fishing is widely regarded as one of the most dangerous professions in the world, even when factoring in the advancement in equipment technology, fishing methods and automation (Berg-Beckhoff et al., 2016). Developed countries with stringent occupational health and safety laws such as the United States of America (USA), Australia and many European countries still record injury and fatality rates within the commercial fishing industry 25-40 times higher than any other industry, with developing countries recording 3 – 10 times higher than those countries (Havold, 2010). The international labour organisation estimates that around 24000 deaths a year worldwide are attributable to fishing activities, with a further 24 million non-fatal injuries occurring each year (Havold, 2010).

Research into occupational safety in the fishing industry was reported in the 1950s on the injury burden of Polish and United Kingdom (UK) workers in deep sea fishing industries. Since then, research into the commercial fishing industry has resulted in many more publications on the topic of occupational safety in the commercial fishing industry (Lucas et al., 2014). Regarding research into the workplace factors related to commercial fishing the common consensus outlined by articles describes an industry of highly physically demanding workloads. Typical work tasks undertaken as part of routine fish harvesting are recognised to require that the worker have a high level of endurance, coordination and strength (Kucera et al., 2009). The working life of a commercial fisherman requires long working hours, which are typically longer than 12 hours in a day and are at irregular times which are usually governed by factors beyond the control of fishing operations (Berg-Beckhoff et al., 2016; Dabholklar et al., 2014).

Life as a fisherman is usually characterised by long periods of time spent away from home (Dabholklar et al., 2014). Professional fisherman are often required to undertake demanding industrial type tasks whilst being exposed to hostile environmental work conditions of cold, heat and precipitation (Kucera et al., 2009). The natural environment hazards of the workplace are confounded by the workplace environment at sea (Østergaard et al., 2016). Workers are required to

perform tasks on an often cluttered, wet and moving deck of a vessel (McGuinness et al., 2013). The unpredictable nature of work at sea and the dynamic load bearing due to manual handling heightens the risk factor for musculoskeletal disorders (MSDs) within the fishing industry which have been identified in multiple research papers as a major area of concern for workers in the fishing industry (Kucera et al., 2009; McGuinness et al., 2013).

Safe Work New South Wales (NSW) (n.d) recognises the physically demanding work environment of commercial fishing and the risk it poses to the worker. The common causes of injury for the forestry fishing and agricultural workers are defined as manual tasks, repetitive motion, hearing loss from machinery and animal handling (Safe Work NSW, n.d). This assessment is concurrent with most international literature that describes a poor ergonomic work environment where most recordable incidents resulting in injury involve lifting and carrying.

Ergonomics is defined by Pheasant (1991, p. 4) as 'fitting the task to the person and the product to the user.' 'Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people' (Human Factors and Ergonomic Society, 2020, p.1).

2. Methodology

The research for this paper consisted of secondary data collected through freely available search engines; Google Scholar was first used to gather data for this paper. All papers in English were included, those not in English were excluded. The topic was defined by the key terms, 'fishing', 'commercial' and 'ergonomic' which resulted in 9,000 initial results. A second search included the term 'risk' that yielded 12,000 results. The key word risks was selected as this was an aid in identifying the ergonomic risks in the workplace of a commercial fisherman. A limitation was placed on searches to only include articles published between 2010 and 2020 to reflect the recent developments of ergonomic consideration for commercial; fishing workplaces and to ensure information included was recent and relevant. This yielded limited sources as most of the publications were then excluded, so an allowance was made to include some older resources due to the scarce nature of published literature regarding workplace human factors in the commercial fishing sector during the last 10 years. After reading article abstracts 13 selected publications from these databases were used in this article.

Further searches were undertaken using the Curtin University online library search which included the key terms 'ergonomic', 'fishing' 'commercial' which returned 812 results. Five resources were selected from this search. These articles were retrieved through an online link to ProQuest, Taylor and Francis online and Elsevier. An exception was made to include an article from 1994 due to the scarce nature of published literature on the impact of ship movements on load bearing. The databases of Safe Work Australia, Safe Work New South Wales, Department of Commerce Western Australia, Department of Agriculture, Water and the Environment and the Australian Maritime Safety Authority were searched. Three publications were used from these searches.

Most of the world's fishing workforce resides in developing countries. The limitations of the article selection criteria may not be entirely representative of the global fishing workforce. This makes the generalisation of the human factors identified difficult due to the non-homogeneity of fishing fleets around the world.

3. Discussion

Introduction

The workplace human factors affecting

commercial fishermen have been investigated and identified by multiple studies in the United States of America (USA), Europe and India (Dabholkar et al., 2014). A wide variety of fishing operations have been studied by these articles which have returned similar findings on the human factors affecting commercial fisherman. Through these findings, the relevant ergonomic factors affecting commercial fisherman have been identified as included in this article.

A Moving Workplace

A moving working environment produces many problems for a worker that include motion sickness, reduced balance and the need to counterbalance ship movements which results in physical fatigue and overall reduction in worker performance (Ning & Mirka, 2010). These problems are often exacerbated in rough weather conditions while fishermen were expected to undertake the same work rate with increasing unpredictability of the movement of the vessel (Matthews et al., 2007). The workplace of a fishing vessel has been described as a "typical example of a risky work environment marked by severe occupational hazards" (Zhang et al., 2010, p. 8). The deck is the primary area where work is undertaken and represents the convergence of mechanical and environmental factors (McGuinness et al., 2013).

The deck of a fishing vessel is a dynamic work environment, workers are in close proximity to moving hydraulic equipment, moving ropes, waves coming onto the deck and other workers (Donald & Dzugan, 2014; McGuinness et al., 2013). The working environment is often cluttered and hard to navigate; confounded with these factors is the constant motion a vessel experiences whilst at sea (McGuinness et al., 2013; Donald 2014). One Norwegian study analysed 2,359 nonfatal injuries of the fishing fleet workers and found that 69% of all injuries occurred on the deck of the fishing vessel (McGuinness et al., 2013). Across all studies, ship motion was identified as a significant hazard of the working environment for a commercial fisherman. When a worker lifts a load in an unstable environment the body responds by over stabilising those joints to cope with the unpredictable environment (Torner, et al., 1994). Research conducted by Torner, et al. (1994) found that a worker performing the same manual lifting tasks undertaken in a static environment experienced a 40 percent increase in spinal compression due to the motions of an environment. Matthews et al. (2007) highlighted the importance of stability when performing manual handling, which are typically the primary tasks undertaken by commercial fishermen. The variability of injury results is high due to smaller ships experiencing increased ship movement and the differences in hull design of fishing vessels (Torner et al., 1994).

The findings of Torner et al., (1994) explicitly link the movement of ships with increased risk of back injury. A study undertaken by Ning and Mirka (2010) found that boat motions tend to amplify the lifting forces encountered from slant surfaces. This finding is in agreeance with previous findings from Matthews et al., (2007) that the pitch condition of a vessel is the most difficult to maintain stability even when not handling a load. However, a cross sectional study of 270 fishermen looking at the prevalence and predictors of muscular skeletal diseases (MSD) among Danish fishermen found no association between ship design and MSD (Berg-Beckhoff et al., 2016). Another study examining reported occupational injuries from the Norwegian fishing fleet from 2000 to 2011 (2,359 non-fatal injuries) conducted by McGuinness et al., (2013) in the Norwegian fishing fleet found that the movement of a fishing vessel requires a fisherman to bend, clamber, stretch, reach, extend and perform heavy physical exertion whilst constantly adjusting to a moving workplace. The exact role the movement of a vessel has on a fisherman physically is somewhat unclear due to some conflicting evidence and the diversity of vessel design in fishing fleets around the world.

Manual Handling

A simplistic view of a fisherman's job is that of someone who catches fish, stores those fish and returns to shore to sell

(Dabholklar et al., 2014). In reality, the job of a fisherman is that of hard physical labour characterised primarily by manual handling (Østergaard et al., 2016). Manual handling is defined as the movement of heavy loads by hand or bodily force (Zhang et al., 2010). The physical job demands on the fisherman leads to various musculoskeletal conditions commonly identified to affect the areas of the back, shoulder, hand and knee (Dabholklar et al., 2014; McGuinness et al., 2013). These problems are almost always associated with lifting of heavy weights or repetition of a particular activity that arises through the repetitive cyclic nature of commercial fishing (Dabholkar et al., 2014). Manual handling is identified in most studies as a significant factor in the prevalence of MSDs amongst fisherman (Dabholkar et al., 2014; Kucera et al., 2009; Østergaard et al., 2016; Torner, et al., 1994;). The handling of heavy materials, being either fishing gear, ice, supplies or boxes are commonplace in the fishing industry and considered a normal part of a fisherman's working day (Ning & Mirka, 2010).

In a Danish cross sectional survey study with 637 participants, manual handling tasks performed by a fisherman were identified by 36 percent of respondents of making up more than half of the workday (Østergaard et al., 2016). In this study the majority of respondents were skippers of the vessels which may mean that working conditions reported in the study may not be applicable to deckhands. An interview study with 105 USA participants who were crab pot and gillnet fisherman found that 90 percent of fisherman reported loading bait/supplies, pulling in/emptying and setting gear and cleaning the boat, while a only a third operated mechanical pullers and net reals for more than half the fishing period (Kucera et al., 2009). A majority of these fisherman did not report using mechanical aids such as a wheeled platform when loading/unloading supplies (Kucera et al., 2009). Those fishermen who performed the aforementioned activities for more than half the period of fishing time were found to be strongly associated with severe lower back pain (Kucera et al., 2009).

Most people attribute a relationship between manual handling injuries to poor knowledge of lifting techniques in the fishing industry, Østergaard et al. (2016) found that 96% of the 637 research participant fishermen indicated they knew how to lift properly but only 55% actually did. Out of the entire sample 42% indicated it was not possible to implement those correct lifting methods in their workplace and 59% stated that lifting aids were not used for heavy loads (Østergaard et al., 2016). This may help to explain the alarmingly high rates of MSDs reported in the fishing industry by almost all studies reviewed. An Indian cross sectional study with 110 randomly selected workers from the fishing industry found that 92% of workers experienced intermittent lower back pain in the last 12 months (Dabholkar et al., 2014). Similarly, in Denmark 80% of the 637 research participant fishermen reported lower back pain in the past year (Østergaard et al., 2016). A cross-sectional survey undertaken in Sweden with 1,243 participants found that 50% of deep-sea fishermen said that they experienced lower back pain symptoms in the past 12 months (Torner et al., 1988 as cited in Kucera et al., 2009). Of these research participants 228 worked only as skippers, 805 worked only as deckhands and the other 210 participants were both skippers and deckhands.

Workloads

Despite the technological advancements in the fishing industry that allow for easier fishing gear haulage, processing of fish and handling of materials, fishing remains a profession linked with high physical workloads (Østergaard et al., 2016; Torner et al., 1994; Ning & Mirka, 2010). Economic success in the fishing industry is defined by the amount of catch hauled on board a fishing vessel (Fulmer & Buchholz, 2002). Many fisheries are heavily regulated in relation to their fishing gear requirements, species of fish and catch limits within the industry (Fulmer & Buchholz, 2002). This level of regulation varies vastly between regions, states and countries (Fulmer & Buchholz, 2002). Most fishing crews will try to maximise the

catch landed whilst minimising time at sea. This results in an increased risk of MSDs due to the increased workload as a result of fishing pressure (Fulmer & Buchholz, 2002).

Heavy physical workloads, in awkward postures for long working hours are typical descriptions of work within the fishing industry (Torner et al., 1994). On a fishing vessel two roles were defined by Østergaard et al. (2016), first the skipper, who is responsible for navigating/identifying fishing ground and planning the daily operations on board. The second role is that of the deckhand, who performs the practical work. This entails setting/retrieving gear, as well as icing and storing of the catch (Østergaard et al., 2016). The perceived workloads self-reported by skippers and deckhands varied significantly in the study undertaken by Østergaard et al. (2016). This is indicative of the variation of roles within the workplace of a commercial fisherman. Dabhoklar et al. (2014) and Østergaard et al. (2016) both describe long hours standing upright, pushing and pulling and bending/twisting of the back for both roles. Even perceived sedentary tasks are demanding at sea. A skipper was found to use 37% of maximum aerobic power whilst steering the vessel (Rdahl & Vokac, 1979 as cited in Torner et al., 1994). This was attributed to counterbalancing the movement of the vessel (Rdahl & Vokac, 1979 as cited in Torner et al., 1994).

The high workloads in the commercial fishing may be linked with psychological stress. Anecdotal evidence in the USA from Fulmer and Buchholz (2002) suggested that many fishing operators faced increased mental stress due to failure of their government to effectively manage the fish resource. Fulmer and Bucholz (2002) identified an area of interest that was that of overfishing. Many operators feared an overreaction in fishing regulations due to a lack of government action would inherently increase economic pressure and force fishermen to expose themselves to more risk as higher workloads were needed to ensure economic survival (Fulmer & Buchholz, 2002).

Work Patterns

Commercial fishing is characterised by irregular working patterns, high levels of stress due to performance goals and heavy workloads (Dabhoklar 2014; McGuinness et al., 2013; Zhang et al., 2010). Dabhoklar et al. (2014) described the work patterns of Indian fishermen as consisting of a 12-hour day of repetitive hard physical labour. In Australia, the Australian Maritime Safety Authority (2020) recognises that seafarers may work long irregular hours, live away from home for weeks or months at a time in an environment that is both their workplace and home. Specific information of the effect fatigue has on fishermen was not obtainable in this publication.

A study in Norway still regarded fishing to not be conductive of good rest periods due to abnormal mealtimes and long working hours (McGuinness et al., 2013). It is noteworthy that Norway does not regulate the working hours of seafarers (McGuinness et al., 2013). Injuries in the Norwegian fishing fleet were found to be highest between 9 am and 6 pm, where workers often forgo the routine lunch and dinner hours (McGuinness et al., 2013). A fisherman structures rest periods when time permits, as work is often undertaken around the clock (McGuinness et al., 2013). The allocation of rest time is more dynamic than in land-based industries which means fisherman often receive less restorative sleep, thus their circadian rhythm is often out of normal synchronisation (McGuinness et al., 2013). The culmination of these factors is a worker who lacks concentration and slower reaction times in a profession that requires situational awareness, concentration and physical strength (McGuinness et al., 2013).

The study undertaken by McGuinness et al. (2013) in Norway was the only literature that was found to specifically identify the irregular working patterns of fisherman and attribute those work hours to increased injuries. Government literature in Australia published by the Australian Maritime Safety Authority (2020) considered the effect of fatigue on seafarers with no specific mention of fisherman. The impact of work patterns and injury in the fishing

industry was identified as a key area in addressing injuries within the Norwegian fishing fleet, the problems of fatigue were also stated as being not dissimilar to fatigue problems in other industries (McGuinness et al., 2013).

Safety Culture

The fishery people are going to take risks, while the fishing is there and take bigger risks than the other people (Murray and Dolomount, 1994 as cited in Håvold, 2010). One study that examined the safety culture aboard fishing vessels through a questionnaire, completed by 209 participants, stated that between 75 and 96% of accidents in the fishing industry were caused by human error (Havold, 2010). The fishing industry was identified as being subject to a multitude of international regulations implemented by the International Maritime Organisation (IMO) (Havold, 2010). These regulations are often difficult to enforce due to the differences between fishing fleets in countries around the world, particularly between developed and developing countries (Havold, 2010). Secondly, fishing work generally takes place far out at sea, out of the reach of most enforcement agencies and most fishing industries are reluctant to adopt safety measures for their fishing fleet (Havold, 2010).

The conclusions made by Havold (2010) were that fishermen accept the risk of their occupation, but often do not treat this risk seriously. Havold (2010) identified eight factors that may influence the safety culture of fisherman at sea. (1) Attitudes to rules and regulation. (2) Attitudes to safety and training drills. (3) Job satisfaction. (4) Fisherman's safety attitude. (5) Cooperation and working conditions. (6) Pressure. (6) Stress and negative influence from work. (7) Conflict between work and safety and (8) management safety attitude. Havold (2010) identified through a questionnaire, that fishermen who were involved in a serious incident in the last 12 months were found to be more positive to safety within the workplace. This is was contrasted against the negative views of fisherman towards rules and regulation. Further findings were that fishermen felt more satisfied with their job when more than one family member was involved in the industry. Money was also identified as a major reason why operators cut corners on maintenance and in turn safety at sea. This was attributed to increasing economic pressure fisherman are facing which is consistent with the anecdotal evidence given by Fulmer (2002) and Havold (2010).

The Fishing Industry in Australia

Data for the fishing sector in Australia is amalgamated with forestry and terrestrial agriculture making distinction between incidents that are reported and factors affecting the fishing industry in Australia challenging.

Workplace human factors in the fishing industry in Australia have been seldom explored. Three studies were identified which assessed work related fatalities in the fishing industry. Between 1982-1984 the fatality rate was 143 per 100,000 person years (Driscoll et al., 1994). From 1989-1992 the fatality rate per 100,000 person years (89.2) compared to all other industry (5.5) (Hull et al., 2001). Finally, from 1992-1998 the fatality rate per 100,000 person years was 56 per 100,000 person years (O'Connor & O'Connor, 2006). These studies show a negative trend of fatality rate amongst commercial fisherman in Australia over time. All studies found that environmental conditions significantly contributed to the fatality of a fisherman but did not solely attribute this factor to fisherman deaths (Driscoll et al., 1994; Hull et al., 2001; O'Connor & O'Connor, 2006). Alcohol and drug usage, unsafe work practises, inadequate emergency procedures and failure to wear personal floatation devices were found to also contribute to the circumstances that produced a death of a fisherman (Driscoll et al., 1994; Hull et al., 2001; O'Connor & O'Connor, 2006). These articles recognised the hazards fishermen face in the workplace as involving a harsh environment and interaction with mechanical systems (O'Connor & O'Connor, 2006). However, the purpose of these articles was to assess fatality rates within the fishing industry and not explore specific ergonomic risk factors in the workplace of a fisherman.

Research into the progress of occupational health and safety in the fishing industry undertaken by Lucas et al., (2014) found that only six articles relating to occupational health and safety were published in Australia. By comparison the USA had over 50, the UK had 30 and Poland had 11. This alludes to a considerable gap in knowledge in relation to workplace human factors in Australia's fishing industry due to this lack of published literature on the topic. It offers opportunities for research to be conducted to identify how work can better be fitted to commercial fishermen's capabilities to improve their productivity and reduce injuries, particularly muscular skeletal injuries.

4. Conclusions

Working in the commercial fishing industry is a dangerous and physically demanding job. Countries such as the USA, Norway, Denmark and India have taken an ergonomic approach to fishing and identified specific human factors that make the job of a commercial fisherman dangerous and demanding.

In Australia, little published literature exists on workplace human factors within the commercial fishing industry and this needs to be addressed to improve fisherman safety. Most international studies identify the role of manual handling, ship movement, workloads and work patterns as influencing the high prevalence deaths and injuries within this industry.

To conclude, the published literature detailing human factors in the fishing industry is limited, especially in developing countries. The lack of literature is surprising considering the extremely high fatality and injury rates reported within the commercial fishing industry. The lack of cohesion in studies of ergonomic factors in the fishing industry needs to be addressed, specifically regarding the role of ship movement. Further exploration into organisational factors that include the safety culture in the commercial fishing industry should move from anecdotal evidence and be verified through scientific research to assess the true effect. Research can identify strategies to make the workplace, work processes and actions of commercial fishermen as safe as reasonably practicable with physical, cognitive, organisational, social and environmental ergonomic factors addressed.

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Possibilities and Challenges of Making Safety a 'Way of Life' in Indian Society

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Abstract

How to make safety as a way of life, whether this objective is a myth or reality? This paper provides the results of an exploration study. Enablers and barriers, examples and experiences are discussed related to the possibilities and challenges of making safety a 'Way of Life' in Indian society. It involved 540 Health, Safety and Environment Professionals using focus group discussions/interviews and webinars. From the results implications are drawn toward the research objectives as well as reflections on the existing safety culture and its challenges and solutions.

Key words: Behavior. Safety culture. Way of life. Society. India. Community. Training.

1. Introduction: Context and Rationale

Without access to any kind of formal training in Occupational Safety and Health (OSH), the overall awareness levels in India are low (Hart, 2018). The ILO Global Commission on the Future of Work report that in all countries, under reporting, particularly of non-fatal occupational accidents and especially work-related diseases, is common. The governments/employers/ workers, and all stakeholders must seize opportunities to create a safe and healthy future workplace and sustainable businesses (Walter, 2019). Countries have to take a new stand on safety-and-health.

"Safety is not a slogan, it is a way of life" is a poster which is seen by, or heard of, by almost everyone who can read or hear. Then why safety is not a way of life. It is bypassed in almost every country. How much "safety is a way of life", differs between countries depending upon the population size, respect for the laws of the land, discipline in individual behaviors, etc. In today's scenario, an average Indian mindset does not consider safety as an essential element that needs to be incorporated in the daily activities and this mindset manifests at various levels of social, commercial and professional hierarchy. Safety policies and practices need to merge. Sehgal (2016, p.6) wrote let us strive to move ahead on the "Path to Safety" and build Safety Consciousness in every citizen of the country.

What is the role of Indian heritage, culture and philosophy for human safety and health? Bhagavad Gita, a great Indian epic, includes that human Karma (actions, behaviors) lead to consequences. Safe Karma leads to safe consequences and vice versa. Here in Madhya Pradesh (MP) State of India, people are getting married in the month of June, in spite of lockdown and all awareness on Covid19. It is not known how to explain the importance of social distancing to them. They don't listen. They say, our ancestors want the children to get married creating a horrible situation. The traditional thinking has overruled safety practices. Behavioral patterns are predominantly driven by values/needs of the culture and traditions of the land. If a person values going for job and not losing it, they are focused on that, and bypass safety measures to achieve whatever it takes. The person has to follow certain traditions, maybe, at the cost of safety, and this is being practiced by many at the same time. In other words, the health/safety needs of people are based on their socioeconomic status. The poor people are less inclined to meet health/safety needs than those whose socioeconomic status is better. In the Mumbai city's dense low-income settlements, safety measures to prevent coronavirus infections are an unachievable privilege (Johari, 2020). Culturally unsafe practices are those that "diminish, demean or disempower the cultural identity and well-

being of an individual" (Nursing Council of New Zealand, 2002, p.628). Williams (1999) defined cultural safety as an environment that is spiritually, socially and emotionally safe, as well as physically safe for people.

The government of India is committed to regulate all economic activities for the management of safety and health risks at workplaces and to provide measures so as to ensure safe and healthy working conditions for every working man and woman in the nation as per National policy on safety, health and environment at the workplace. But, the citizens need adequate infrastructure and life support systems to conduct themselves in safe and healthy ways. Also, it would not be possible to achieve 'safety as a way of life' without the corporate social responsibility (CSR) and social change initiatives at community levels. Indian cities rank low according to Safe Cities Index. Mumbai ranks 45th and Delhi 52nd on the Economist Intelligence Unit's Safe Cities Index, which ranks 60 countries worldwide across indicators including digital, infrastructure, health and personal security (Khanna, 2019).

The safety topic was discussed as hundreds of thousands of fatalities occurred across countries due to coronavirus risk exposure, in spite of rigorous awareness campaigns by governments to wear masks, maintain physical distancing etc. On the 18th of December, 2020, the John Hopkins University COVID-19 Dashboard showed that there were 9,956,557 cases in India (74,875 world wide) and 144,451 COVID-19 related deaths (world wide 1,660,032 deaths) from March in 2020 in India.

Normally, we say "safety as a way of life". We want to know, what do we mean by this. Secondly, have we done any activity to promote 'safety as a way of life' beyond our cites. Safety awareness should extend beyond the workplace (Van Oord, 2020).
A safety professional provides an anecdote, "can enforcement bring behavioral safety culture in the community at this stage? Yes, if the residential building management puts the rules in writing and enforcing done through housing society security, the discipline is well maintained. Butpractically, does it get sustained? There are one, two violations that happened in the past and a warning notice was put in the WhatsApp group to conduct safe behaviors and inform others of the same" (Maheshwaran, 2020, p1).

2. Research Objectives

Despite emphasis by Indian culture and laws, there are problems in seeing safety culture as a way of life among Indian society, the implications of which are seen in terms of hundred thousands of fatalities due to Covid19. Hence this research leads to find out ways for the same.

Research objective one. To identify ways to make safety a way of life in the Indian Society.

Behavioral safety culture in industry has been successfully practiced but how it can be followed as a way of life among sociocultural settings, is a difficult research question which was approached for this article? This question became increasingly relevant during Covid19 scenario among all countries.

Research objective two. To identify how a behavioral safety culture can be included in sociocultural settings.

3. Methodology

Participants, measures, procedure, analysis

Focused group discussions (FGD)/ interviews/ webinars with 540 Health, Safety and Environment (HSE) professionals/ trainers were conducted through remote data collection techniques over 2-months (May-June 2020) in India from diverse locations and organizations. FGDs are used to understand an issue at a deeper level than can be achieved with a survey (Monishankar & Garcia, 2017). Broad themes/sub-themes were identified for data interpretations. Behavioral safety training methodology for planned interventions were followed at sites (see figures 1 and 2).

4. Results and Findings

The results and findings of this qualitative research study are presented in three broad themes or categories as stated here below:

- Enablers and Barriers
- Examples and Experiences
- Behaviour Based Safety Management

Enablers and Barriers in making safety and health a way of life in India

Jansz et al. (2020) presented an exhaustive list of enablers and barriers of 12 countries for workplace safety and health. In India, the safety professionals during the FGDs envisaged positive and negative correlates of establishing a safety culture in terms of the enablers and barriers as stated here below.

<u>*Enablers*</u> or Leading Indicators are: the education right from school days, efforts by non-government organisations (NGO) and the Government on health, motivation by Institutions and industries, promotion of safety by elders at home after current COVID19 education was provided. Other enablers are:

*Improvement trend in community awareness,
*Increase in community engagement programs in health and safety,
*Improvement in infrastructures,
*New technologies,
*Building of cultures including people getting sensitized and management control,
*Belief in Omni-energy (God), respect to mythology,
*Respect for Elders,
*Belief in "Vasudheiva Kutumbakam" (world as one family)
*Market requirements,
*Goodwill.

<u>*Barriers*</u> or Lagging Indicators are poverty, behavior of educated people, Indian tradition and customs, lack of safety leadership by top management of industries, non-stringent enforcement of law, corruption among law enforcers and government spending on health and safety. Some more barriers are:

*Negative example setting by leaders,
*Low literacy,
*Risk taking nature,
*Lack of risk assessment ability,
*Tendency to act safe only under supervision,
*Lack of systematic approach,
*Believing in quick wins (shortcuts),
*Priorities of management towards production and quality,
*Low and loose involvement of governments' body towards standards,
*Do not take Hygiene related issues seriously,
*Do not get safety education since childhood,
*Education system as a whole does not speak about basic Safety Standards and Precautions,
*Insurance,
*Human cost,
*Failure of Enforcement agency (Corruption).

One needs to ponder over an upward trends of incidents and fatalities over the past decades. It needs to be understood that the above set of barriers are responsible for deteriorating safety and health environment as well as hundred thousand fatalities every year that can be averted provided there are focused efforts to contain these barriers and at the same time, the enablers of safety and health are taken forward by all concerned.

Examples and Experiences of HSE professionals on 'safety as a way of life'

From the 340 Health, Safety and Environment Professionals that took part in focus group discussions, the following are the seven main sub-themes of experiences to emerge, in addition to the above-said enablers and barriers in making safety and health a way of life in India.

<u>*Sub-theme 1*</u>

In my building, all delivery is done at gate. No delivery personnel are allowed to enter the building. If plumber or service provider

to come in to the building, mask is a must and his hands are sanitized by the security personnel. If he is coming from a containment zone, he is not allowed. Any residents coming back to the building after visiting worst affected places such as Chennai or Ahmedabad, 14 days quarantine is mandatory. No visitors are allowed inside the building. All residents shall wear masks when they go out of the building.

Sub-theme 2

I have done programs for behavioral aspect of road safety. This program was conducted in school, colleges and some of residential societies. This was done as a service to the nation to improve safety perceptions.

Sub-theme 3

The COVID-19 itself has taught us the many examples as lessons of societal behavior. Like people are keeping away from others. Using mask and reminding others who are not using. Most of the people are keeping mask with them all times. People started cleaning hand with sanitizers. Many more such examples are there.

Sub-theme 4

Raising concerns and real life story sharing and learnings. Some still don't relate as they feel, this will not happen to me. Many people worked without domestic help for last 3 months and now are desperate. But still few senior citizen still manage without maids as they think it is a high risk and can reduce one of the chance of infection.

Sub-theme 5

Enforcement is key to the successful implementation of any initiative in India due to our mind set which is different from the world. Inherited from our predecessors but is changing now and a time consuming process.

Sub-theme 6

Corona virus numbers in India are rising. Why? We are in community transmission phase, though Government is not agreeing. Government is trying to open the market, on basis of building back the lost economy. But people think that COVID19 has come down and that's why Government has opened up the market. So communication is not clear. Myth is that COVID19 cannot affect me. People are in stress due to this lockdown. When someone is in prolonged stress, their body immunity becomes weak. So even a minor infection could result in major.

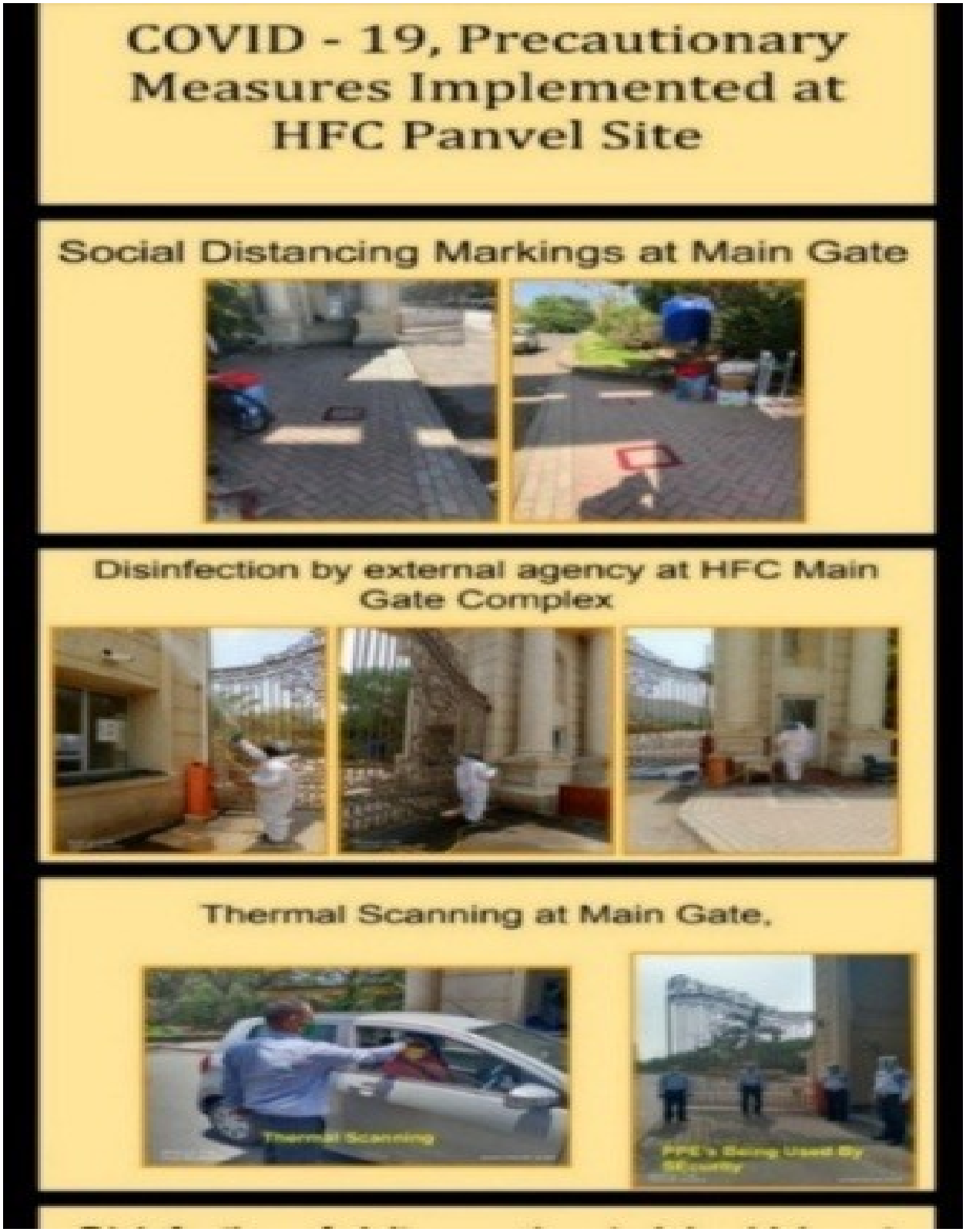
Sub-theme 7

Some safety professionals voiced, *we have received the Certificates of Safety, but major question is, how to make safety a way of life in India? Whether by changing attitude and creating awareness about safety? Indian Society, very difficult as people are focused on GOD. Nevertheless, we transformed organizations, we would transform society too*.

Hiranandani Fortune City (HFC) has assimilated all COVID-19 related safe behaviors for its residents and the staff (See Figure 1) to make it as a way of life.

In spite of the HSE professionals' efforts, it is relevant to note that as per recent estimates released by the ILO, each year 2.78 million workers die from occupational accidents and work-related diseases (of which 2.4 million are disease-related) and an additional 374 million workers suffer from non-fatal occupational accidents (ILO, 2019). 'Safety as a way of life' objective seems far away. Nevertheless, 'Safety to be a way of life' is to be in the syllabus for all education levels as a reinforcement constantly from school to university to employment, etc. Life-long learning helps to achieve such global perspective to save human lives. Education is the great equalizer, wrote the American educational reformer Horace Mann (1848). A motherly-motivational observer who would use social-media to reflect observations / spot-correction of self and others daily is all what is needed everywhere in society to make safety a way of life.

Figure 1:
COVID-19 related safe behaviors



Source: I*mage shared by a FGD respondents from a construction site of Tata Projects*

5. HSE Professionals Question Behavior Based Safety Management

Behavior based safety (BBS) can spread from industry to community through awareness webinars, sessions by trained BBS Mentors and experts for developing observers in communities for observation and spot-correction to make safety and health a way of life (Kaila, 2019). In this regard, the HSE professionals clarified the below questions and answers that arose as the result of the focus group discussions.

•Do you think behavior based safety management (BBSM) is the future of safety culture?
HSE professionals' answer.
Yes, as behavior is the root cause of all incidents, as also emphasized in ISO45001. Also culture drives the behaviors, hence BBS implementation focuses on developing safety culture.

•How can an organization successfully implement BBSM?
HSE professionals' answer.
In three phases.
Introduction of behavioral safety to top management and development of roadmap.
Rolling out BBS in entire workforce.
Sustain it by monitoring and rewarding employees every month.

•What are the challenges faced during the implementation of BBSM?
HSE professionals' answer.
Challenges were passive involvement of Head of Departments (HODs) not letting behavior based safety management be known till the last person at site shows appreciation of observations by seniors.

•What are the advantages of successful implementing BBSM?
HSE professionals' answer.
Advantages are incidents control, saving from injuries, increased productivity without loss. As long as, there is a focus on BBSM, that would bring business outcomes and positive implications. Further, link BBS with CSR and its community application especially in Covid19 scenario.

• Who benefits through BBSM?
HSE professionals' answer.
Employees, management, contractors, even casual visitors and all stakeholders benefit.

•What type of environment requires a change in its safety culture?
HSE professionals' answer.
A reactive and dependent safety culture/environment.

•What are the important aspects of BBSM?:
HSE professionals' answer.
The important aspects are observation, observers and spot-correction of at-risk behaviors. Forming BBS steering team, and sensitivity and communication of leaders for implementation. Overall, behavioral safety and health approach is a 'caring' way of life and an art of positive living. It is an intense conversation and counselling for getting rid of any risks around.

•Who should take the first step in implementing BBSM?
HSE professionals' answer.
Top management by involving all HODs and stakeholders.

•Do you think BBSM implementation has improved over the past decade?
HSE professionals' answer.
Yes, almost 10,000 units in India have implemented and frequency and severity of incidents have significantly reduced at sites.

•Why do you think BBSM must be an integral part of safety systems?
HSE professionals' answer.
BBS focus is on behavioral issues of safety, no other systems do that. Moreover BBS alone can't bring total safety culture so BBS is to be integrated with safety systems. Question remains whether safe conditions prevail to live safely or are we privileged for conditions to live safely. Essentially, safe behaviors plus safe conditions would rebuild safe-societies.

6. Conclusions, Recommendations and Implications for social policy and planning

Research conclusions and recommendations in this section should help to identify ways to make safety a way of life in the Indian Society, and to identify how a behavioral safety culture can be included in sociocultural settings.

Conclusions related to research objective one

Research objective one was to identify ways to make safety a way of life in the Indian Society.

Managing safety culture is a big challenge, as it is hard for people to perceive the safety and health risks, for those who belong to communities that do not emphasize an interdependent safety culture. It is personal behavioral safety pattern of individuals that is influenced by social cognition and culture. Social cognition perspectives shape social milieu and social response. Most behavioral applications use social cognition frameworks for social change management, like establishing behavioral safety culture as a way of life in societies (Vinney, 2020). Department of Science and Technology, Govt. of India (2020) emphasized that safety should evolve as a habit of every person, and needs to be propagated as the culture. Safety should be of prime concern as it plays an important role in the socio-economic sectors in a significant way that will affect the growth of the institutions and have an impact on a national level. Thus, safety implementation and financial performances are correlated vertically and horizontally.

Difference between safety cultures of Indian and other countries needs to be understood. Yet, to date, the relationship between national culture and safety culture has received relatively little attention. The researchers have examined the relationship between organizational culture and the dimensions of national culture (Mark et al., 2015). Organizational culture and behavior in multinational organizations vary according to the national cultural norms of the countries. Associations exist between safety culture and Hofstede's (2001) five critical dimensions of national culture namely Power Distance, Individualism - Collectivism, Masculinity, Uncertainty Avoidance, Long-term Orientation. Moreover, the management of occupational safety and health in a culturally diverse working environment demands an approach that includes multiple voices, and one in which it is possible to considerably broaden the knowledge base for alternative decisions and to increase the number of possible paths leading to solutions to problems (European Agency for Safety and Health at Work, 2020).

Conclusions related to research objective two

Research objective 2 was to identify how a behavioral safety culture can be included in sociocultural settings.

Research conclusions are that 'safety-culture-as-a-way-of-life' mission is possible to prevail among societies when it is not reactive, least dependent on others, its independent and also interdependent. The distancing between these cultures is crucial to manage. This mission is possible when it begins with family, school and social values and a long-term orientation and uncertainty situations are not avoided. It is a planned intervention. When this is achieved the societies are believed to be safe for their futures. The unplanned would not be safe. 'Safety as a way of life' is a conscious effort of everyone.

The findings of this research could raise certain questions as to whether the Indian way-to-life itself is on right path. 148,000 people were killed in traffic accidents in India during 2019. By 2030, traffic deaths are expected to account 1.25 million deaths across the world each year according to the World Health Organization (2020). Fortunately, a planned intervention called the Swedish Indian Transport Innovation and Safety Partnership (SITIS), comprised of companies that include Volvo Group, Autoliv, SAAB, Manipal Hospitals, and Altair; research institutes such as Chalmers, RISE, IIT-TRIPP and IISC and authorities such as VTI, ARAI, Swedish

Administration Authority, and Niti Aayog, could help put a stop to these unnecessary suffering (Hogman, 2020) and make road safety a way of life.

Though there are efforts being put in the direction that would ensure "safety to be a part of our daily lives", it is a long time multi-pronged journey for countries. It is increasingly recognised that the ambitious initiatives such as safety-as-a-way-of-life is complexly determined by socio-cultural factors at many different levels of scale (Lomas, 2015). Toward this, some specific suggestions are described below that could help consolidate our deeds and increase the probability to make safety a way of life.

Recommendations

"Safety and health - a way of life" needs to be definable, observable, correctable on-the-spot, measurable, implementable and sustainable. The difference between a planned/long-term and unplanned/short-term behavioral safety and health culture intervention, is to be made for effective social change program as a way of life (New Brunswick Department of Education Instructional Resources Branch, 2000). For an example, Health & Safety - Choices for Life: An activity-based resource was developed for New Brunswick schools, grades K to 12 to make it as a way of life for children. This is the right time to introduce safety and health in schools syllabus in India.

There is a need to work with people down the levels in their language to make safety culture as a way of life (Jansz et al. 2020). India witnesses a life casualty every 4 minutes in a road accident. Mother India Care is working as a pressure group to educate and encourage the people in general, and drivers in particulars, for safe driving (Mother India Care, 2020).

There are a hundred thousand or more community groups across the globe that organize people towards social goals and indirectly contribute to providing safe mind sets and behaviors. On the other hand, certain sections of society that are not organized, or part of any planned group, and remain at higher risk whenever any health or safety disaster occurs. (WHO, 2020). CSR projects in India focused on community development, skill development as well as road safety (Mitra, 2018).

Several companies organized behavioral safety programs for organisational transformation and emphasised need to involve everyone empowering them to bring a change. Many companies' sites initiated behavioral safety culture programs for communities under CSR and BBS Project activities like road/home safety/employee families/villages/school/college etc.

Figure 2: *Empowering employees to be the change catalysts (Author's photo).*

Dorf Ketal, under CSR, adopted certain schools, and prepared a manual for them that covered precautions to be taken by all students/teachers, staff and parents with regard to COVID-19. Precautions included what they should do at home, during travel, in school and after returning back to home. It focused on how to maintain social distancing, sanitization, use of mask, hand wash, disinfection of vehicles, school premises etc. the objective was to see behavioral safety as way of life. Dorf Ketal's quality, health, safety, security and environmental systems are purposely designed to maintain corporate and community resiliency for the long-haul in every country where they operate (Dorf Ketal, 2020).

In order to make safety and health a way of life, the change leaders/catalysts need to monitor regularly, monitor personally, monitor frequently, monitor numbers of

change, interact with change observers team, make site visits, be an inclusive catalyst with vision and mission (Hariton, 2020). Leaders need to review whether empowerment is going down, core incompetence of organizations need to be managed, evaluate to develop, and check whether most human abilities are being wasted rather than being used.

Strong leaders drive culture of safety and health. They influence to make it a way of life through their programs and actions. Organisational cultures and community expectations are powerful drivers of change and collectively influence the nation's health and safety culture (Safe Work Australia, 2020). Organizations, through their CSR activities, need to raise community's awareness levels on safety and health. Frequency and clarity of communication of safety behaviors among communities improve safety culture.

Critically speaking, the enablers and barriers would keep interplaying and safety and health at-risk behaviours would continue as it is, depending upon the cultural values and compliances of the country's population, and so would be implications in terms of incidents, injuries and fatalities, as being witnessed. Developing and maintaining HSE culture remains a continual journey for all. However, a collective mind set of the world leaders might help move India out of an array of the multiple crises (HSE crisis, natural and political disasters) that have gathered the humanity. The losses are certain and immense whether they are of human lives or economic ones. It would obviously be a long term affairs and testing times ahead across the globe. An elevated mind is a solution toward the united goals with myriad wisdoms, that would prevail with a practice of education, meditation and continuation of persuasion, for safe life of everyone with a sense of equality and quality of caring, and making it a way of life (Long, 2015). For example, the UN-Volunteers supported the COVID-19 response efforts through the network of Indian District Youth Volunteer Coordinators (UNV, 2020) as a social reform.

Thus, the safety/health culture is to be elevated to a symbolic level of solar energy for an immense power, so as to make safety-a-way-of-life in communities with support of government/non-government bodies. A new thinking, focus and energy are needed to meet this goal in question, which would involve many factors like change concept and process, leaders, educational tools, timeframes, coordinators and volunteers, monitoring and tracking procedures, government controls, projects management strategies etc. In this regard, an exemplary services of India needs a mention of the hundred thousands of Accredited Social Health Activists who are large scale grass root community health workers (CHWs like ASHA/AWW/ANMs) across the nation to combat the health disaster (Government of India, 2020). Similar multilevel national safety initiatives would help and are a need of the times. It is crucial to unite more such initiatives, and the national budget must support considerably to make 'safety and health a way of life'.

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Safe Distance Analysis and Modelling of Fire and Explosion of the LPG Storage Tanks at PT XYZ Gresik Regency East Java, Indonesia Using ALOHA (*Areal Locations of Hazardous Atmosphere.)*

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Abstract

Oil and gas industries are categorized as high risk activities. Fire and explosion incident in Liquefied Petroleum Gas (LPG) storage tanks illustrates the high safety risks of Liquefied Petroleum Gas storage tanks at oil and gas processing facilities. PT XYZ is an oil and gas company that has LPG storage tanks, which have a potential for fire and explosion incident. Therefore it is necessary to study the possible impact of fire and explosion incident. This research was conducted to analyze safe distance, and modeling the size of fire and explosion of LPG storage tanks at PT XYZ, and determine the appropriate control measure to reduce the impact of the incident, using Areal Location of Hazardous Atmospheres (ALOHA) Software simulation. The result of this study can also be an input for the Company to ensure the level of safety and reliability of their installation. There were 3 (three) steps in this research. Identification of fire and explosion incident scenario in the LPG storage tanks, the range of fire and explosion modeling of the LPG storage tanks, and the safe distance analysis of LPG storage tanks to other facilities in the vicinity. The results of the research showed that explosion of and fire in the tank caused the spread of heat radiation to the farthest distance of 188 meters from the location of the leak. The worst impact for residents of the settlement is the potential to cause second-degree burns with a thermal radiation level of> 5.0 kW / m2 within 60 seconds. The LPG tank explosion and fire distance models are: a distance of 0- 1.3 km high risk; 1.3-2.8 moderate risk; and> = 2.8 km low risk.

Keywords: LPG Storage Tank. Safe Distance. Fire. Explosion. ALOHA.

1. Introduction

Development of oil and gas industries is very large in Indonesia. The oil and gas industry is a dominant factor in the strategy of Indonesia's development, especially in the globalization and free trade era. The activities of oil and gas industries starting from production, processing, and transportation, all have potential hazards, such as fire and explosion. To prevent or reduce these potential hazards, oil and gas industries have to develop process safety management.

The oil and gas sector is a large industry that has a high risks in processing and drilling activities. In the past ten years, there have been many accident for this industry, such as fire, blasting, environmental pollution and others causes which are a high potential hazards. In past five years 17 of 36 accident were in the drilling area with enormous losses. In Indonesia, especially in the oil and gas sector, each company is required to conduct a risk assessment before a production facility is built and operated, such as identifying, analyzing and evaluating hazards in each work activity (Ramli, 2010).

Law No. 1 of 1970 concerning Work Safety states that one of the requirements for work safety is to prevent, reduce and extinguish fires, as well as to prevent and reduce the danger of blasting (Article 3, Law No. 1 of

1970). The regulation becomes one of the basis for the mandatory efforts to control risk against fire and explosion hazards. Violation of the regulation has an impact on giving sanctions (legal actions) in accordance with Article 15, Law no. 1 of 1970.

In addition, based on the Instruction of the Head of Oil and Gas Inspection No. 69 / 18.01 / DMT / 2013 concerning efforts to increase vigilance over the process safety in LPG storage, both new and existing LPG storage installations with storage capacity more than 4,000 g.w.c. (gallons water capacity) must be assessed with the FSA (Fire Safety Analysis).

Fire and explosion cases due to LPG leak had occurred at the LPG distribution terminal owned by Pemex Oil Company, Mexico on November 19, 1984. The incident originated from the pipeline damage that caused the occurrence of a boiling liquid expanding vapor explosion (BLEVE) which can occur when pressurized liquid inside of a pipe or storage tank reaches temperatures higher than that liquid's boiling point. This was followed by dozens of other explosions, so that as many as 500 people were killed, 5000-7000 suffered seriously injuries and the LPG distribution terminal was destroyed. Losses were US $ 31 Billion and the BLEVE destroyed one third of Mexico's LPG supply (Ramli, 2017).

On April 9, 1998, an 18,000 gallon LPG (propane) storage tank explosion and fire occurred in Albert City, Lowa, United States. The incident began with a tank leak that caused fire and explosion, resulting in 2 firefighters being killed, 7 others seriously injured and material losses from this incident were $ 250,000 (Permatasari, et al., 2016). Some of major accidents in oil and gas exploitation and exploration indonesia are a gas leak during transfer (loading) from an LPG tanker to a 60-ton holding tank owned by PT Surya Artha Chanya, Bogor in 2012. This incident caused hundreds of residents to fret and three people fainted due to the smell of mercaptan in LPG.

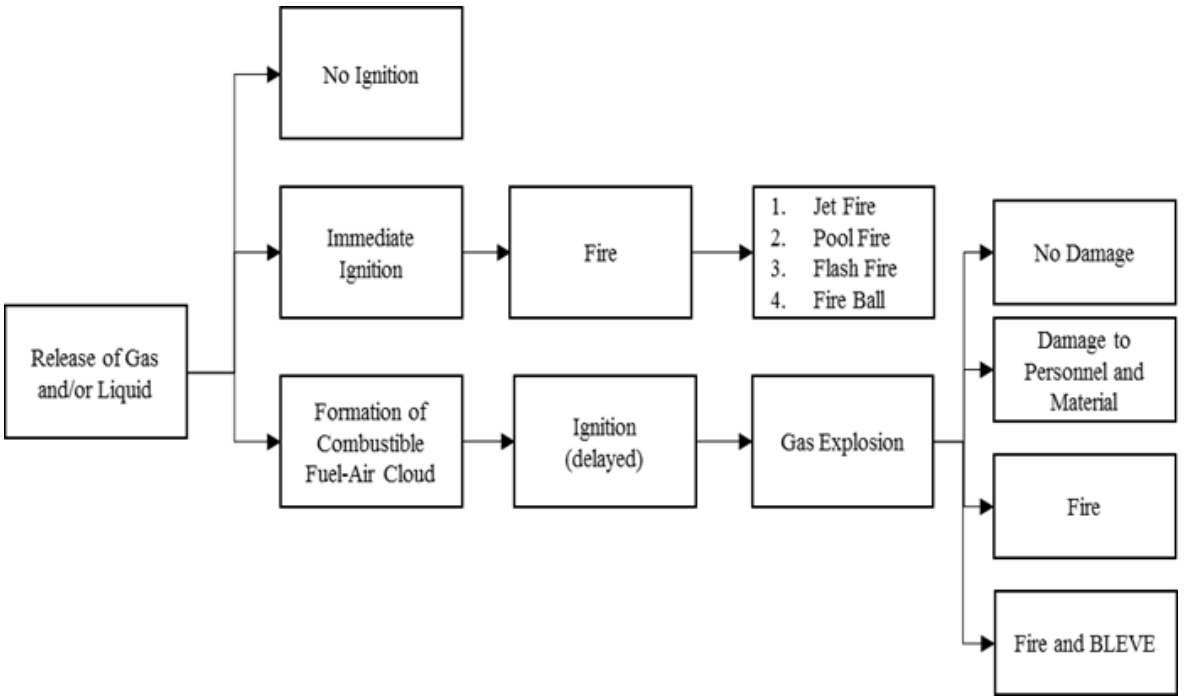
In addition, on November 20, 2015 there was an explosion at the Tanjung Sekong LPG Terminal. This LPG terminal was the largest LPG terminal in Indonesia. It was equipped with 4 storage tanks and jetty facilities to unload and load LPG. Fire was caused by the presence of hydrocarbon gas mixed with air which forms a mixture of explosive gases. This incident caused 2 people to suffer serious burns (Tim Independen Pengendalian Keselamatan Migas, 2017). A fire case at one of the LPG processing facilities at PT XYZ had occurred on March 7, 2018 which caused many losses, including: cessation of LPG production due to damage to some equipment. Environmental factors have an enormous influences on the safety of the drilling process. Environmental factors include human activity and many buildings around the drilling location (Winarno, Deny & Kurniawan, 2016). The main problem faced by PT XZ is increasing public activity around the drilling location which interferes with drilling safety. The purpose of this research was to determine the model of safe distance of LPG Storage tank location from public activites.

2. Literature Review

The oil and gas drilling industry is a high-risk activity because gas pipelines often leak which can result in fire and blasting (Ansori; 2016). The hydrocarbons release in the petroleum industry consists of gas, mist or liquid under atmospheric or pressurized conditions. The release of gas and mist is considered to be more hazardous because the substance is easily ignited (Ramli, 2010). In addition, the presence of a vapor cloud which, if it is ignited, will have a worse impact than liquid fires which are less likely to spread, are usually local and relatively manageable. Such release can be caused by external corrosion, internal erosion, metallurgical damage and by operator error.

According to Bjerketvedt et al. (2006), releasing flammable gas or liquid evaporation into the atmosphere will cause several dangerous events as show in the following figure 1.

Figure 1.
Gas Explosion Tree.



From *Gas Explosion Handbook* (p.20) by Bjerketvedt, et al., 2006, GexCon. Copyright 2006 *GexCon*.

In Indonesia among the most frequent disasters in the gas industry are fires due to the release of hydrocarbon (Ramli, 2010; Ansori, 2016; Permatasari et al 2016). Generally there are 4 types of fires due to hydrocarbon release (Bjerketvedt, et al., 2006).

(1)Flash Fire. This type of fire occurs when a hydrocarbon vapor is in the air or when a vapor cloud suddenly ignites. The fire will glow like lightning in the navel of the fire and usually lasts a short time. This type of fire will release high heat energy which reaches 0.1 - 0.3 psi, so that it can scorch nearby objects or people . These fires often occur in cases of indoors LPG gas leaks (Ramli, 2010).

(2)Jet Fire. If the hydrocarbon comes out through a small hole with high pressure it is called a jet fire (Ramli, 2010). Fire in the oil and gas industry is usually always associated with this type of jet fire. Jet fire is a pressurized flow of flammable gas or atomized liquid (such as the release of high pressure from a gas pipe or an oil well blast event) that burns. If the discharge occurs and then ignited immediately after it occurs (within 2-3 minutes), the result is a jet fire. The jet fire is stable to a point close to the source of release, until the release stops. Jet fires usually occur very locally, but are very damaging to everything that is nearby (Nolan, 2014).

(3) **Pool Fire,** occurs when a hydrocarbon liquid spills and hits a place or in an open container such as a storage tank. The amount of fire is determined by the amount of fuel, chemical, physical properties of the material and by the environmental conditions such as wind direction and weather (Ramli, 2010).

(4) **Fire Ball,** usually occurs due to pressurized gas in a container that suddenly leaks due to rupture. For example LPG tanks that suddenly leak, causing the gas to rapidly expand into the air and suddenly catch fire. One of the fireball causes is the BLEVE (Boiling Liquid Expanding Vapor

Explosion) event (Ramli, 2010).

Assael & Kakosimos (2010) added another one called **BLEVE** which occurs as a consequence of failure caused by external factors (such as fire) of pressurized containers filled with gas or liquid which are stored at a higher pressure than the environment. The absorption of heat causes boiling and an increase in internal pressure. This is associated with a decrease in the resistance of the metal surface due to increased temperatures resulting in container damage and explosion. The release of energy produces very fast airwaves, heat radiation, and fragments from flying containers. Kamaei, et al. (2016) stated that a tank explosion occurred, due to a high-pressure explosion wave.

Another danger for the gas industry is an explosion when there is very high pressure on the pipeline. Bakke, van Wingerden, Hoorelbeke & Brewerton (2010) stated that the impact of a gas explosion is a very broad impact, and even at greater range.

Determining the fire and explosion size of LPG tanks can be done by simulating the modeling of fire and explosion size using ALOHA (Areal Location of Hazardous Atmospheres) Software. The results of this analysis can predict the risk zone (threat zone) due to fire and explosion of the LPG storage tank. The risk areas are then mapped with MARPLOT Software Bhattacharya & Kumar, (2015) wrote that ALOHA software can be used to simulate hazardous chemicals release to the atmosphere. This software is widely used by DOE (Department of Energy) Complex for safety analysis applications. United States Environmental Protection Agency (EPA), through the Chemical Preparedness and Prevention Office (CEPPO), and the National Oceanic and Atmosphere Administration (NOAA) office).

To determine the safe distance, the LPG installation technical guidance from the Directorate General of Oil and Gas through the Instruction of the Head of Oil and Gas Inspection No. 69 / 18.01 / DMT / 2013 was used. The instruction states that in the context of increasing process safety level in LPG storage, both new and existing LPG storage installations with storage capacity of more than 4,000 g.w.c. (gallons water capacity) must be assessed with the FSA (Fire Safety Analysis). In addition to these guidelines, there are a number of standards related to LPG installations, such as: NFPA (National Fire Protection Association) 58 and API (American Petroleum Institute) 2510 as a reference for the Company in carrying out the FSA and determining the safe distance of LPG tanks to other facilities and equipment around it.

3. Methodology

This research used a quantitative approach and was conducted by collecting data at the location of the oil and gas drilling industry XYZ located in Gresik, East Java Indonesia. Data collection and analysis included simulations using ALOHA and MARPLOT Software and interpreting the simulation results for the fire and explosion size due to LPG storage tank leak at PT XYZ and determining the safe distance by referring to the technical guidelines for LPG installations from the Directorate General (Ditjen) of Oil and Gas as well as international standards related to the installation of LPG tanks, i.e. the National Fire Protection Association (NFPA) 58 and the American Petroleum Institute (API) 2510.

Data obtained was analyzed using analytical tools in accordance with the variables to be examined and the conceptual framework. The stages of data analysis were as follows:

- LPG Tank Fire and Explosion Risk Analysis. The process for analyzing the risk of fire and explosion of LPG tanks was by reviewing historical HAZID and HAZOP study data at PT XYZ.
- Modeling of LPG Tank Fire and Explosion Size. The process to find out

the impact of fire and explosion of LPG tanks was by simulating fire size models using ALOHA and MARPLOT Software.

- Analysis of Safe Distance LPG Storage Tanks. The process for analyzing the safe distance of LPG tanks to the surrounding facilities refered to the technical guidelines for LPG installations from the relevant Directorate General (DG) of Oil and Gas (NFPA 58 and API 2510).

4. Results and Discussion

PT XYZ is an oil and gas drilling company that was established on the 27th of June in 2011. It is located in East Java with an area of 784 km2 and consists of onshore facilities (Onshore Processing Facilities [OPF]). Gas Processing Facility (GPF). Oil Treating Facilities (OTF). LPG Facilities (LPGF). Metering,Export pipeline to PLN Gresik. Loading Facility at Maspion Jetty and offshore facilities (Well Head Platform A (WHP-A). Well Head Platform B (WHP-B). Central Processing Facilities (CPP). Accomodation and Utility Platform (AUP).

LPG produced from the processing facilities at OPF and is stored in a storage tank before being flowed to the PT. Pertamina that is managed by PT. Miratama Energy Maspion (MEM). The types and characteristics of LPG storage tanks at PT XYZ are Spherical Tanks with a diameter of 18 meters. The type of Liquid stored in these tanks is LPG (Propane & Butane); Tanks have an Inlet Nozzle that is 6 inches and an Outlet Nozzle that is 12 inches.

Based on PT XYZ's Basis of Design document (Doc. No. UPD-TJ-P2-PR-BD-0001), weather conditions data at the site that were taken from BMKG (Meteorology, Climatology & Geophysics Agency) calculations were made. Weather conditions data can be seen in the following Table 1 that indicates that the temperature is not too hot and the humidity is sufficient.

Table 1. *Weather conditions around the factory*

Parameter	Minimum	Average	Maximum
Temperature (°C)	17.2	28	37.8
Humidity (%)	56	87	93
Wind Speed (m/s)	0.51	5.51	19.02
Note : ▪ Wind direction : from south east to west; ▪ Wind stability at everage wind speed (5.51 m/s) : D.			

Determining Scenario of Events

The event scenario is based on the point or location of the leak in the LPG storage tank and its leak size (diameter) which refers to the International Association of Oil and Gas Producers Report No. 434-1 regarding Process Release Frequencies. The following is a table of event scenarios that was simulated by using ALOHA and MARPLOT Software:

Table 2. *List of Scenario*

No.	Scenario	Leak Location	Leak Height (m)	Leak Diameter (cm)	Remarks
1.	*Jet Fire*	*Bottom of the Tank*	0	0.5	Scenario 1
2.				5	Scenario 2
3.				15	Scenario 3
4.		*Middle of the Tank*	9	0.5	Scenario 4
5.				5	Scenario 5
6.				15	Scenario 6
7.		*Top of the Tank*	18	0.5	Scenario 7
8.				5	Scenario 8
9.				15	Scenario 9
10.	*Fire Ball (BLEVE)*	-	-	-	Scenario 10

Based on scenarios (table2) the simulation results of PT XYZ LPG tank fire and explosion size can be seen in the following table:

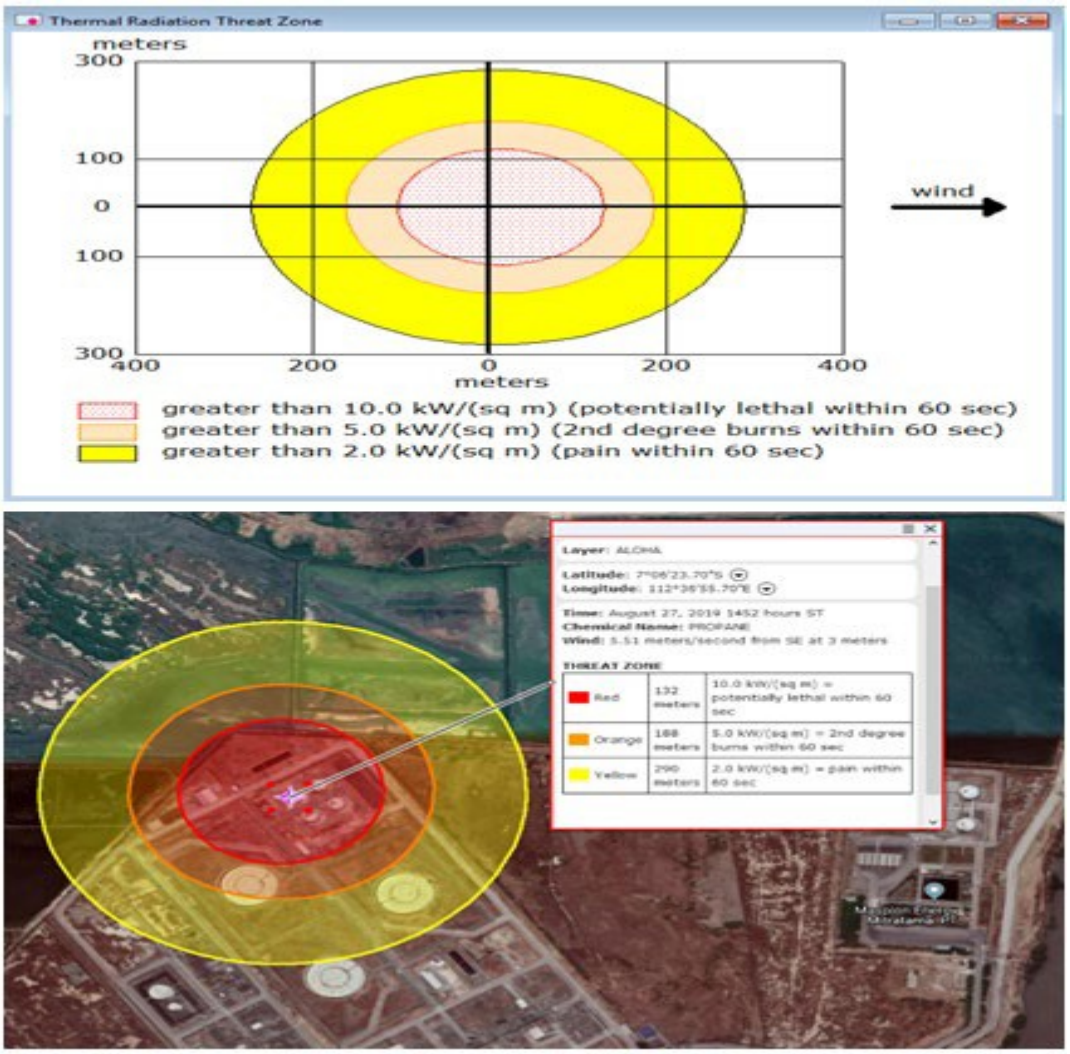
Table 3. *Analysis of Modeling Result*

No.	Scenario	Leak Location	Leak Height	Leak Diameter	Scenario	Size Distance			Impacted Area
			meter (m)	centimeter (cm)		Red Zone (100% LEL)	Orange Zone (60% LEL)	Yellow Zone (10% LEL)	
1	Jet Fire	Bottom of the Tank	0	0.5	Scenario 1	**<10 meter**	**<10 meter**	**12 meter**	LPG Tanks Area
2				5	Scenario 2	**38 meter**	**67 meter**	**102 meter**	Crude Oil Tanks Area
3				15	Scenario 3	**132 meter**	**188 meter**	**290 meter**	Residential Area
4		Middle of the Tank	9	0.5	Scenario 4	**<10 meter**	**<10 meter**	**12 meter**	LPG Tanks Area
5				5	Scenario 5	**48 meter**	**66 meter**	**101 meter**	Crude Oil Tanks Area
6				15	Scenario 6	**131 meter**	**186 meter**	**287 meter**	Residential Area
7		Top of the Tank	18	0.5	Scenario 7	**<10 meter**	**<10 meter**	**11 meter**	LPG Tanks Area
8				5	Scenario 8	**46 meter**	**63 meter**	**97 meter**	Crude Oil Tanks Area
9				15	Scenario 9	**125 meter**	**178 meter**	**274 meter**	Residential Area
10	Fire Ball (BLEVE)	-	-	-	Scenario 10	**1,3 kilometer**	**1,8 kilometer**	**2,8 kilometer**	All Industrial Estate and Residential Area

From 10 scenarios that have been simulated by the ALOHA soft ware, it can be concluded that each scenario has different results. One of the distinguishing parameters is the difference in the location of the leakage point, the height of the leak and the diameter of the leak.The difference of these event scenarios is the leak height (in meters) and leak size (in centimeters).

The worst impact of the fire and explosion from the above modeling results showed that the furthest thermal radiation is seen in scenario 3, which is up to 188 meters from the leakage location. The simulated jetfire event in scenario 3 shows that its thermal radiation size can reach residential areas around PT XYZ. The worst impact of this scenario for residents is the potential of second-degree burns with thermal radiation exposure of of > 5.0 kW / m2 (orange zone) within 60 seconds,as shown in figure 3.

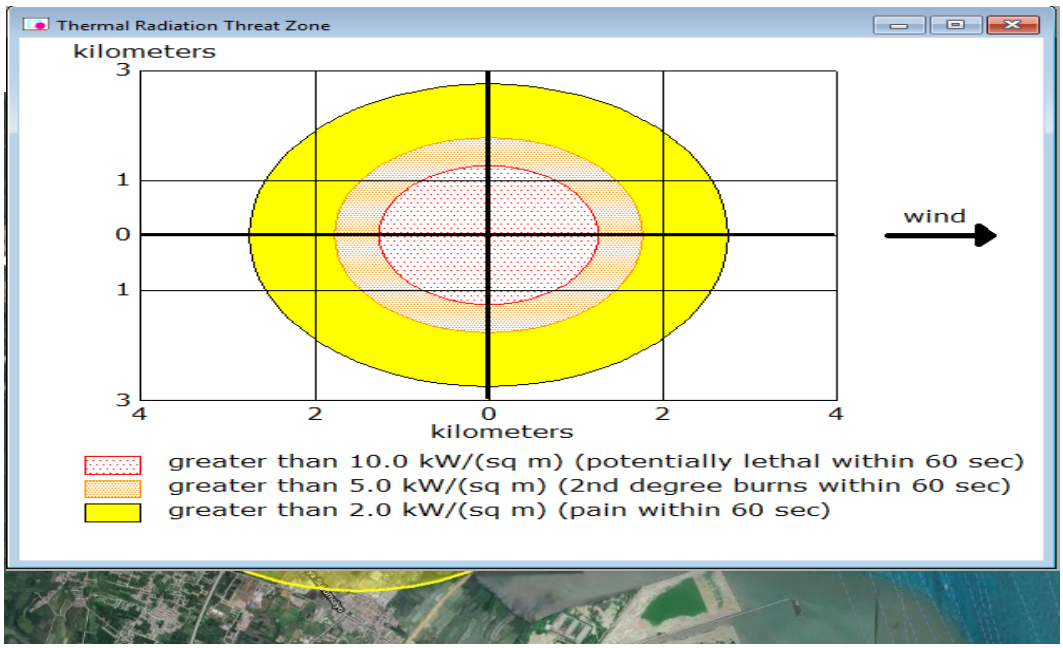
Figure 2.
"JET FIRE" Modeling Scenario 3 using ALOHA Software



The thermal radiation size based on the jet fire modelling (figure 2) includes:Red Zone with size Distance 132 meters. It is an affected area with thermal radiation > 10.0 kW / m2 and within 60 seconds has the potential to cause death. While orange Zone is size with distance 188 meters, and it is an area affected by thermal radiation > 5.0 kW / m2 and within 60 seconds has the potential to cause second-degree burns. The yellow Zone is size distance 290 meters, where it is an affected area with thermal radiation > 2.0 kW / m2 and within 60 seconds has the potential to cause pain. Explosion size modeling by using ALOHA and MARPLOT software shows that the furthest thermal radiation is seen in scenario 10 (figure 3), i.e. the fireball event caused by BLEVE. The simulated BLEVE event in scenario 10 shows that its thermal radiation

size can reach all industrial area and residential areas around PT XYZ. The worst impact of this scenario for residents and all industrial area has the potential to cause death with thermal radiation exposure of of > 10 kW / m2 (red zone) within 60 seconds.

Figure 3.
"BLEVE" Modeling Scenario 10 by ALOHA and MARPLOT



The thermal radiation size based on the explosion "BELVE" modeling are:
(a) red Zone is size distance 1.3 kilometers. It is an affected area with thermal radiation > 10.0 kW / m2 and within 60 seconds has the potential to cause death,
(b)Orange Zone is size distance 1,8 kilometers, it is an area affected by thermal radiation > 5.0 kW / m2 and within 60 seconds has the potential to cause second-degree burns, and
(c) Yellow Zone is size distance 2,8 kilometers, and it is an affected area with thermal radiation > 2.0 kW / m2 and within 60 seconds has the potential to cause pain.

Safe Distance Analysis

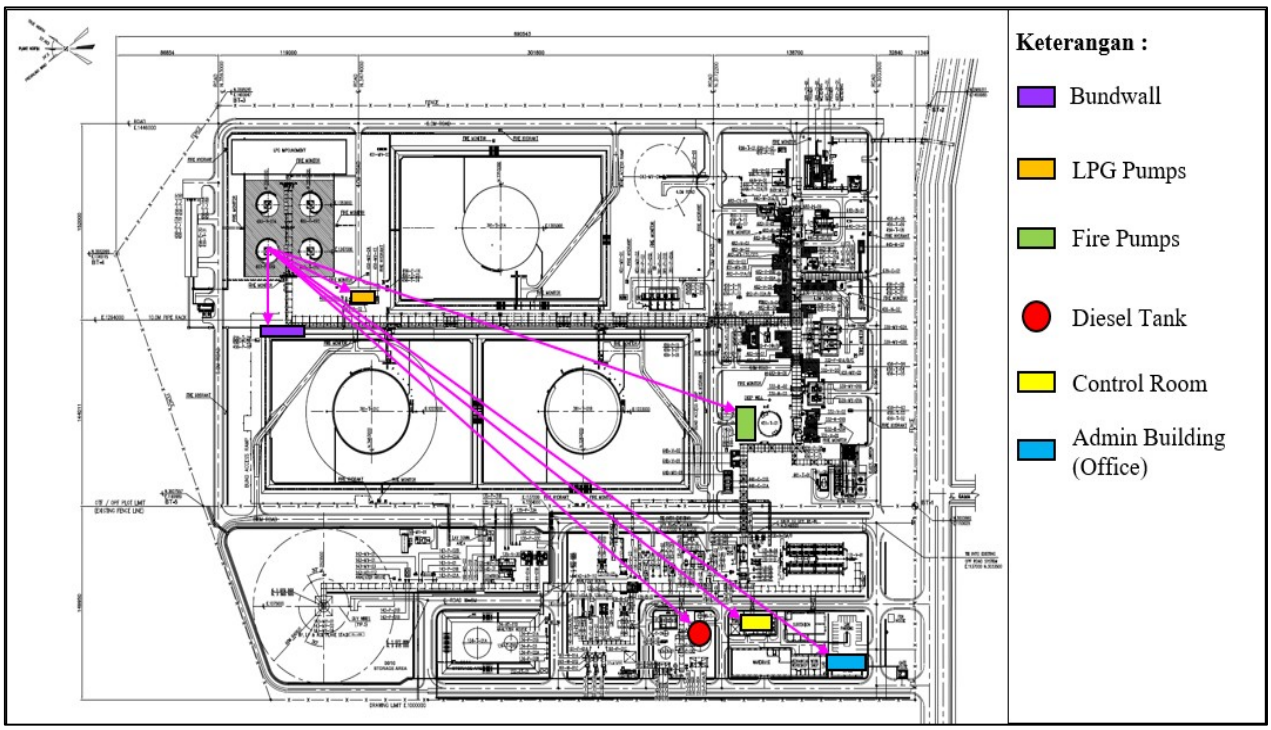
To determine the safe distance, the LPG installation technical guidelines from the Directorate General of Oil and Gas through the Instruction of the Head of Oil and Gas Inspection No. 69 / 18.01 / DMT / 2013 and several standards related to LPG tank installations, i.e. NFPA (National Fire Protection Association) 58 and API (American Petroleum Institute) 2510, are used.

Table 4. *Safe Distance Analysis Result*

FROM	TO	TECHNICAL GUIDELINE (NFPA 58)			STANDARD (API 2510)			ACTUAL		STATUS	REMARKS
		Clause	m	Actual	Clause	ft	m	ft	m		
LPG tank (120.000 or greater)	Building at North Area	5.6.1	122	-	5.1.2.1	200	61	-	-	-	No Building Exist
	Building at West Area	5.6.1	122	-	5.1.2.1	200	61	-	-	-	No Building Exist
	Building at East Area	5.6.1	122	-	5.1.2.1	200	61	-	-	-	No Building Exist
	SHELL Petroleum Facilities	5.6.1	122	766	5.1.2.1	200	61	2513.12	766	Comply	
	LPG Sphere Tanks Maspion	5.6.1	122	709	5.1.2.1	200	61	2326.12	709	Comply	
	Palm Oil	5.6.1	122	600	5.1.2.1	200	61	1968.5	600	Comply	
	Public Road	5.6.1	122	552	5.1.2.1	200	61	1814.3	553	Comply	
	LPG Tank	5.6.2	1/4D	17	5.1.2.2	5 ft or 1/2 D		55.77	17	Comply	
	Diesel Tank	5.6.3	6	458	5.1.2.3	1/2 D the largest tank		1502.62	458	Comply	
	Control Room	5.6.2	122	491	5.1.2.4	50	15	1610.89	491	Comply	
	Office	5.6.2	-	569	5.1.2.4	100	30	1866.8	569	Comply	
	LPG Pumps	5.6.2	-	73	5.1.2.5	10	3	239.5	73	Comply	
	Fire Pump	5.6.2	-	415	5.1.2.5	50	15	11361.55	415	Comply	
	Bund Wall Crude Oil Storage Tanks	5.6.2	-	51	5.1.2.6	10	3	167.323	51	Comply	

Based on the above results, it can be concluded that the LPG storage tank of PT XYZ has fulfilled the Fire Safety Analysis (FSA) requirements related to safe distance analysis. The mapping of PT XYZ's LPG storage tank safe distance can be seen in the following OPF (Onshore Processing Facilities) Layout (Figure 4).

Figure 4. *Safe Distance Mapping of LPG Storage Tank*



5. Conclusions

Based on previous safety studies (HAZOP and HAZID Study) of PT XYZ, several potential hazards in PT XYZ LPG storage tanks are identified as causing potential fire and explosion.

Fire size modeling by using ALOHA and MARPLOT software shows that the furthest thermal radiation is seen in scenario 3, which is up to 188 meters from the leakage location. The simulated jetfire event in scenario 3 shows that its heat radiation size can reach residential areas around PT XYZ. The worst impact of this scenario for residents is the potential of second-degree burns with thermal radiation exposure of of > 5.0 kW / m2 (orange zone) within 60 seconds.

Explosion size modeling by using ALOHA and MARPLOT software shows that the furthest thermal radiation is seen in scenario 10, i.e. the fireball event caused by BLEVE. The thermal radiation size includes:

- Red Zone: Size Distance 1.3 kilometers. It is an affected area with thermal radiation > 10.0 kW / m2 and within 60 seconds has the potential to cause death.
- Orange Zone: Size Distance 1,8 kilometers. It is an area affected by thermal radiation > 5.0 kW / m2 and within 60 seconds has the potential to cause second-degree burns; and
- Yellow Zone: Size Distance 2,8 kilometers. It is an affected area with thermal radiation > 2.0 kW / m2 and within 60 seconds has the potential to cause pain.

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Who is responsible? An examination of the 'Chain of Responsibility' in heavy vehicle crashes - an Australian perspective

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Abstract

The aim of this study was to examine the role of the 'Chain of Responsibility' legislation in heavy vehicle crashes within the Heavy Vehicle Transport System. The Heavy Vehicle National Law and the Compliance and Enforcement legislation, commonly referred to as the 'Chain of Responsibility' legislation, were compared to identify differences and determine whether the legislation created a transparent system that identified those responsible in the chain of events leading up to a heavy vehicle crash. The roles and responsibilities of nominated parties, identified as 'actors' were mapped using Rasmussen's ActorMap framework, which added to mapping a structural hierarchy identifying the various actors and their responsibilities. The study identified that both the Heavy Vehicle National Law and the Compliance and Enforcement legislation-imposed duties and obligations on the same actors within the Heavy Vehicle Transport System, however there were differences in the requirements the legislation imposed. Additionally, it was identified there was a lack of vertical integration from the lower levels of the Heavy Vehicle Transport System to the upper levels of the system. In particular, there was no feedback loop to Regulators and the Government of information needed to inform strategy and policy development to improve heavy vehicle safety. It is clear the legislation imposes obligations on actors beyond the driver and yet in reality the heavy vehicle driver is still the focus of blame.

This study recommended the need to implement national harmonisation of the legislation and the introduction of an independent national investigation agency to investigate heavy vehicle crashes. It also recommended the need to implement a national reporting and data base system where heavy vehicle crash information can be analysed.

Key words: Chain of Responsibility. Heavy Vehicles. Compliance. Safety, Crashes.

1. Introduction

Fatal and serious injuries resulting from heavy vehicle crashes represent a significant workplace and societal problem both in Australia and globally. Within Australia the Heavy Vehicle Transport System has been identified as the most dangerous industry, with the highest death rate of its workers compared to that of other industries (Transport Workers Union [TWU], 2015b). From March 2017 to March 2018 there were 184 deaths from 163 fatal crashes (Bureau of Infrastructure Transport and Regional Economics [BITRE], 2018). According to the IBIS World report into Road Freight Transport in Australia (IBIS, 2017), the national freight task is projected to double by 2030 which will see an increase in growth of heavy vehicles on Australian roads. With this prediction it is reasonable to expect that the number and proportion of heavy vehicles will significantly increase the pressure on the road transport system which is likely to increase the number of crash-related deaths and injuries. Internationally, the statistics cause great concern. In the United States, data released by the National Highway Traffic Safety Administration (2017) identified there were 4,317 heavy vehicle crash-related fatalities recorded in 2016, which represented a 5.4 percent increase from 2015. In the United Kingdom in 2013, more than 5,200 people were killed in crashes involving heavy vehicles (European Road Safety Observatory [ERSO], 2017).

The current legislative regimes for the Heavy Vehicle Transport System that focus on road safety are designed to protect workers and the broader community through organisational

implementation of structures that mitigate crashes and injuries (Stuckey and LaMontagne, 2005). Legislative frameworks are designed so that decisions made at the top level of the system (e.g., policies, strategies etc.), that emanate from Government, set the boundaries for safety within the heavy vehicle industry and identify what is required of the heavy vehicle industry to be compliant (Anderson and Bailey, 2005). It is expected that decisions made by Government and the Regulators cascade to the actors in the lower levels of the system (i.e. supply chain and other networks etc.) who implement internal policies to manage driver behaviour and mitigate crash and injury risk. For example, New Zealand's legislation identifies the roles and responsibilities of parties, including customers, and what they must do to prevent a driver from committing a breach of their legislation (NZTA, 2009). In 2012, South Africa implemented new legislation for transport operators that extended liability to industry actors and third parties (Onanchenko, 2012). Similarly, Canada implemented a Road Safety Strategy (RSS) in 2015 in which all stakeholders were encouraged to 'Rethink Road Safety' and included recommendations to change driver behaviour and split responsibilities between parties who are involved in the transport of freight (Onanchenko, 2012; Canadian Council of Motor Transport Administrator [CCMTA], 2011).

Although the safety responsibilities of these actors are clear under these legislative regimes, it is unclear whether these responsibilities are enforced or monitored to ensure that the actors are compliant. This question is important to answer, considering that research conducted in the United States and Australia has established that there are multiple factors across the Heavy Vehicle Transport System that contribute to heavy vehicle crashes (Newnam and Goode, 2015; Newnam et al., 2017); many of which involve lack of oversight in legislative compliance, such as load restraint, mass and dimension management and vehicle maintenance. It is important to note that the efficacy of the legislation in supporting a safe working environment has not yet been conclusively validated.

The aim of the current study was to identify and map the roles and responsibilities of actors in the Heavy Vehicle National Law, Compliance and Enforcement legislation that has been implemented in Australia. This study was used to illustrate the strengths and weaknesses of the legislation, as well as identify opportunities for improvement.

2. Background

2.1 The Australian Context

Australia has a vast geographic expanse with numerous isolated communities where heavy vehicles are the only practical mode of freight transport and distribution that can reach every location. The Australian heavy vehicle transport industry employs in excess of 149,871 employees, has over 46,087 businesses and an annual market revenue of approximately AUD$42 billion (IBIS, 2017).

In an attempt to reduce the number of deaths and injuries within the heavy vehicle transport industry, Governments around Australia, in consultation with key industry stakeholders, have implemented legislation to make all parties involved in the movement of freight, responsible for breaches of the legislation. Specifically, the laws recognise that it is not just the driver who is responsible for road safety breaches and crashes; they assert that those who exercise control or have influence over the transport task are also responsible. Therefore, the objective of the laws is to ensure all parties in the supply chain share equal responsibility for road safety by ensuring compliance in every aspect of the Heavy Vehicle Transport System. This legislative framework is colloquially known as the 'Chain of Responsibility' (National Heavy Vehicle Regulator [NHVR], 2017).

In Australia, the Chain of Responsibility is captured under two differing pieces of legislation. These are the National Heavy Vehicle Law Act 2012 (and its accompanying Regulations) and Western Australia's Compliance and Enforcement legislation, which includes the Road Traffic [Vehicles] Act 2012 and Road Traffic (Vehicles) Regulations 2014.

Currently the Heavy Vehicle National Law is

applicable in the Australian states of Queensland, New South Wales, Victoria, South Australia, Tasmania and the Australian Capital Territory. Western Australia did not implement the Heavy Vehicle National Law. Its freight system differs to that of the eastern states in that the Heavy Vehicle Transport System includes the movement of larger road train configurations (including mass and dimensions) over greater distances. Another difference is that 95 – 98 % of the West Australian freight tasks occur within Western Australia, in contrast to the eastern states which have more developed transport infrastructure to handle the freight volumes and a higher percentage of interstate transport (Freight and Logistics Council of Western Australia Inc [FLCWA], 2017a; FLCWA, 2017b; Gardner, 2015). The Northern Territory did not implement either law as the benefits of implementing the legislation could not be substantiated. Therefore, this study did not consider heavy vehicle transport in the Northern Territory.

The Heavy Vehicle National Law and the Compliance and Enforcement legislation in Western Australia are both complex pieces of legislation and can be difficult for the associated stakeholders and actors to interpret. Of the combined 1,834 sections from both pieces of legislation there are 434 sections that are focused on specific elements of the Chain of Responsibility (e.g. mass, dimension, load restraint).

The Heavy Vehicle National Law also includes the elements of speed and fatigue whereas both speed and fatigue are excluded from the Compliance and Enforcement legislation. These differences are discussed further in this paper.

This study focused on the various actors defined in the legislation, their legislated responsibilities and how these responsibilities integrate between actors and the various levels of the Heavy Vehicle Transport System. This study also considered if there were any reporting requirements within the legislation; what those reporting requirements were; to whom those reporting requirements were assigned; and what data is collected. This was done to identify if vertical integration exists within the Heavy Vehicle National Law and the Compliance and Enforcement legislation.

Western Australia's Compliance and Enforcement legislation has some points of difference as it does not include fatigue or speeding and only refers to load restraint, mass and dimensions. Another difference is the Compliance and Enforcement legislation applies to all vehicles irrespective of size or type whereas the Heavy Vehicle National Law only applies to vehicles with a gross vehicle mass equal to and exceeding 4.5 tonnes. These differences are referred to in Table 1.

Table 1. *Differences between the Western Australian Compliance and Enforcement legislation and the Heavy Vehicle National Law.*

What is applicable	WA C&E Law	HVNL
Applies to all vehicles including vans, utilities, trailers.	Yes	No
Applies to vehicles exceeding 4.5 tons gross vehicle mass.	Yes	Yes
Fatigue laws applies to all vehicles exceeding 4.5 tons.	Yes	No
Fatigue laws applies to vehicles exceeding 12 tons gross vehicle mass.	No	Yes
Mass.	Yes	Yes
Dimension.	Yes	Yes
Load Restraint.	Yes	Yes
Speeding.	No	Yes
Fatigue.	No	Yes
Container Freight Declarations.	Yes	Yes

(Heavy Vehicle National Law 2012, Road Traffic (Vehicles) Regulations 2014, Main Roads Western Australia [MRWA] 2014)

In addition to the driver, the Heavy Vehicle National Law and the Compliance and Enforcement legislation identifies the supply chain parties, employers, loaders, packers, managers, supervisors, consignors, consignees, receivers and owners who have responsibilities under the legislation. The Chain of Responsibility recognises that the actions, inactions and demands of these actors can influence and impact the driver's on-road behavior and adversely impact on road safety (Anderson and Bailey, 2005).

2.2 Systems-approach to Heavy Vehicle Safety

Cassano-Piche et al. (2009) suggest that Rasmussen's Risk Management Framework is a useful way to systematically analyse the Heavy Vehicle Transport System because it is able to represent the relationships between the levels of the system and between the various actors prescribed in the Heavy Vehicle National Law and Compliance and Enforcement legislation.

The Heavy Vehicle Transport System has been described as a complex socio-technical system of technical, psychological and social elements that is unpredictable and influences safety outcomes (Newnam and Goode, 2015). Rasmussen's (1997) Risk Management Framework is a systems-based analysis approach that was designed to analyse the series of interacting events and decision-making processes involving all actors throughout socio-technical systems such as this. The Risk Management Framework does not solely focus on the front-line workers (Newnam and Goode, 2015; Underwood and Waterson, 2014; Bradford et al., 2009). It examines contributing factors from multiple factors, not just the one action, inaction, error or incorrect decision that contributed to the incident (Newnam and Goode, 2015).

The Risk Management Framework examines contributing factors in the hierarchy of actors within the system whose decisions, actions and relationships interact with other actors across the levels to influence safety. It identifies that decisions made at higher levels of the system are reflected in the behaviours of actors in the lower levels, while the decisions by actors at the lower levels should inform actions and decisions by actors at the higher levels of the system. This process is known as vertical integration (Rasmussen, 1997).

Research conducted by Newnam and colleagues (Newnam and Goode, 2015; Newnam et al., 2017) suggests that driver accountability in the transportation industry is only one element in the system and additional focus should be given to understanding the enforcement and monitoring processes of other actors, if prevention efforts are to be optimised. To illustrate, the work environment for a heavy vehicle driver exposes them to external pressures that pose many risks. These risks may include: driving long distances, being isolated, striving to meet unrealistic deadlines and delivery schedules i.e. fatigue, stress, working to unregulated freight rates and remuneration or the carriage of perishables and dangerous goods as well as the potential crash and injury risk posed by other road users (Stevenson et al., 2010). This is supported by Quinlan and Wright (2008) as well as Jones et al. (2003) who have suggested that drivers who exhibited poor driving behaviours and who breached the legislation did so because of multiple pressures such as: financial impact of low freight rates, intensive competition, poor loading and unloading practices, unrealistic schedules and the impact of increased workloads caused by the growing demand for services and organisational profitability. Despite this, blame for breaches in road safety historically has focused almost exclusively on the driver whilst other contributory system factors have largely been overlooked (Newnam and Goode, 2015; Scott-Parker et al., 2015).

All factors in the system need to be considered if a reduction in crashes is to be achieved. One method of approaching this issue within the Heavy Vehicle Transport System is to apply Rasmussen's (1997) ActorMap, a key component of the Risk Management Framework, as well as examine the extent of the vertical integration between the levels of the system.

Additionally, the Heavy Vehicle Transport System presents an ideal exemplar for application of the ActorMap, given the size, breadth and scope as well as the number of

deaths that occur within the industry (TWU, 2015a).

4. An Overview of the Heavy Vehicle Transport System

1. The Heavy Vehicle Transport System

In 2015 Newnam and Goode applied Rasmussen's ActorMap to the Heavy Vehicle Transport System. Their analysis was based on Coroners' investigation reports into heavy vehicle crashes and identified six levels that represent the actors and their responsibilities within the Heavy Vehicle Transport System. The six levels as defined in Newnam and Goode's (2015) framework are outlined in Table 2.

Newnam and Goode's (2015) sixth level (Environment, Road and Vehicle) is not considered in this study, as no actors are identified within the Heavy Vehicle National Law and the Compliance and Enforcement legislation at this level of the system.

Table 2: *The actors in the Heavy Vehicle Transport System and their responsibilities at the specific levels.*

Levels of the Heavy Vehicle Transport System	The Responsibilities of the Levels
1. Government	Policy development and decision making regarding heavy vehicle transport safety, including the development of legislation and oversight of regulatory and enforcement bodies
2. Regulator/Enforcement	Enforcement and management of legislative requirements of actors to ensure compliance with the laws, planning strategy, implementing government policy involving action and decisions made by personnel working for regulatory agencies.
3. Supply Chain Parties	Adapting to the legislation, integrating and promoting compliance within the industry and workplace, planning, budgeting. Making decisions, actions, inactions and demands that may have an impact on heavy vehicle transport safety activities, setting remuneration methods, freight rates, working conditions and contractual requirements.
4. Heavy Vehicle Companies	These included the Board of Directors and Executive Officers who are required to Integrate and embed legislative requirements within the organisation, ensuring compliance, adhering to the regulatory mandate set and enforced by the regulators. Implementing processes, policies and systems to ensure organisation-wide compliance. To ensure the actions, inactions and demands made by upper level management, including the board, supervisors, other employees (such as loaders, packers, schedulers etc.) do not cause a driver to breach the Chain of Responsibility. Also includes interventions such as budgets, company policy, procedures, training, education, skills competencies and scheduling.
5. Drivers	Actions and decisions, being compliant to the legislation, following and abiding by the policies and processes implemented by the organisation however the overarching compliance being mandated by government legislation. Directly involves heavy vehicle operators such as the driver co-driver, other road users, truck owners, contractors, and sub-contractors etc.
6. Environment/Road/Vehicle	Road design, environmental conditions, speed zones, rest areas, maintenance, servicing, vehicle being fit for purpose etc.

Newnam and Goode (2015) Heavy Vehicle Transport System ActorMap.

2. Method and Data Sources

In this study the roles and responsibilities of actors in the Chain of Responsibility were mapped using Rasmussen's ActorMap (Rasmussen, 1997) and the two main components of Waterson and Jenkins' (2010) framework, which added to the mapping a structural hierarchy describing the various

actors and their responsibilities. The mapping

provided an overview of the actors involved in the Heavy Vehicle Transport System and was used to validate the relationships between the actors as required in the responsibilities set by the Heavy Vehicle National Law, the Compliance and Enforcement legislation and their subordinate Acts and Regulations.

Additionally, a logic diagram was devised using the AcciMap process, developed by Rasmussen (1997), to illustrate the links between the actors of the various levels of the Heavy Vehicle Transport System. To review and access the most recent versions of the above legislation the documents were obtained from the Regulators' websites, being the National Heavy Vehicle Regulator and Main Roads, Western Australia, websites as well as legal websites such as 'Austlii' which were also accessed to obtain up to date copies of the legislation. These sites were checked monthly to capture any amendments.

4. Results and Discussion

1.Actors Identified within the Legislation Mapped Against the Levels of the Heavy Vehicle Transport System

The mapping of the Chain of Responsibility in this study revealed some differences between the actors identified by the Heavy Vehicle National Law and the Compliance and Enforcement legislation, as Table 3 shows.

Table 3 - *Actors identified within the legislation mapped against the levels of the Heavy Vehicle Transport System.*

Heavy Vehicle Transport System Levels	Actors identified in the National Heavy Vehicle Law	Actors identified in the Compliance and Enforcement Legislation
Government	• National Heavy Vehicle Regulator.	
Regulator/Enforcement	• A person appointed under HVA accreditation for monitoring or other responsibilities under the accreditation i.e., certifying, approving or monitoring the use of a heavy vehicle. • National heavy vehicle regulator (s656) - providing administrative services for the operation of law. • Authorised Officer. • National Heavy Vehicle Regulator.	• Police. • Member of the police force of another jurisdiction. • Wardens. • Public Authority.
Supply Chain Parties	• Owner, operator or occupier of a weigh bridge. • A person who provides to an owner or registered operator of a vehicle, or a combination an intelligent transport system. • An owner or operator of a weighbridge, or weighing facility, used to weigh the vehicle, or an occupier of premises where such a weighbridge or weighing facility is located.	• Owner, operator or occupier of a weigh bridge. • A person who provides to an owner or registered operator of a vehicle, or a combination and intelligent transport system. • An owner or operator of a weighbridge, or weighing facility used to weigh the vehicle, or an occupier of premises where such a weighbridge or weighing facility is located.
Heavy Vehicle Companies	• Consignor, consignee, packer, loader, loading manager, operator, manager, scheduler, partners (business partnerships), executive officers,	• Consignor, consignee, packer, loader, loading manager, operator, manager, partners

	employer, contractor, owner of a heavy vehicle or any part of a combination or registered operator of a heavy vehicle or any part of a combination of a heavy vehicle. • A person in charge of the base of the vehicle driver. • A person in charge of a place entered by an authorised officer of the law. ● A prime contractor of the driver if the driver is a self-employed driver. • A person in charge, or apparently in charge, of the vehicle or of a base of the driver of the vehicle. ● A person who is accredited under Part 4 Division 4 in relation to the vehicle. ● A person who is responsible for performing a function of a prescribed kind in relation to the vehicle by way of complying with a requirement of accreditation. ● An employer, employee, agent or subcontractor of all of the above.	(business partnerships), executive officers, employer. • Contractor, owner of a heavy vehicle or any part of a combination or registered operator of a heavy vehicle or any part of a combination of a heavy vehicle. ● A person in charge of the base of the vehicle driver. ● A person in charge of a place entered by an authorised officer of the law. ● A prime contractor of the driver if the driver is a self-employed driver. ● A person in charge, or apparently in charge, of the vehicle or of a base of the Driver of the vehicle. ● An employer, employee, agent or subcontractor of all of the above.
Drivers and Co-Drivers	• Driver and co-driver. • A person who is involved in the transport of goods by road by means of a vehicle.	• Driver and co-driver. • A person who is involved in the transport of goods by road by means of a vehicle.

4.2 Responsibilities of Actors Identified within the Legislation

The mapping of the Chain of Responsibility in this study also revealed some differences in the responsibilities of the actors between those identified in the Heavy Vehicle National Law and the Compliance and Enforcement legislation, as Table 4 shows.

Table 4. *Actors within the legislation and their respective responsibilities under the relevant legislation*.

Heavy Vehicle Transport System Actors	Responsibilities identified within the Heavy Vehicle National Law	Responsibilities identified within the Compliance and Enforcement legislation
Government	• Administration and delegation of legislation.	• Provide delegation authorities to the regulator. • Administration and delegation of legislation.
Regulator/ Enforcement	**Part 12.2 National Heavy Vehicle Regulator s659 Functions of Regulator subsection 2)** • Monitor and review and report to the responsible Ministers compliance and non-compliance to the legislation. • Monitor and investigate compliance with this Law. • Identify and promote best practice methods	• Wardens and Police Officers can exercise powers to ensure and enforce compliance to mass dimension and loading requirement.

	• Manage risks to public safety arising from the use of heavy vehicles on roads. • Encourage and promote safe and productive business practices. • Collaborate with other law enforcement agencies to ensure a nationally consistent approach. • Collaborate with road managers, the National Transport Commission and industry.	
Supply Chain Parties	• Must not cause a driver to breach any part of the law.	• Must not cause a driver to breach any part of the law.
Heavy Vehicle Companies		
Loader	• Must ensure loading will not cause or contribute to the driver driving while impaired by fatigue. • Loading manager must work with other off-road parties to manage loading/unloading time slots. • Ensure vehicles are loaded/unloaded as quickly and efficiently as possible. • Putting systems in place for unexpected events. • Ensure vehicle loads do not exceed a vehicle's mass or dimensions. • Ensure the load is placed in a way that it does not become displaced, unstable or move or fall off the vehicle.	• Loaders have the responsibility for ensuring a vehicle's load. • Does not exceed vehicle or permitted dimension limits. • Does not cause vehicle or permitted mass limits to be exceeded. • Is placed /secured in a way that it does not become unstable, move or fall off a vehicle. • Is accurately recorded in any manifest and other documentation relating to that load. • When packed in a freight container, it does not exceed or cause the containers gross weight or safety approval rating to be exceeded.
Packer	• Ensure the weight information of freight is reliable. • Ensure the documentation about the vehicle's load is not false or misleading. • Any goods packed in a freight container do not cause the container's gross weight or safety approval rating to be exceeded.	• A packer has the same duties as the loader.
Consignor	• Ensure loads do not exceed vehicle mass or dimensions limits. • Goods carried on are appropriately secured. • Operators carrying freight containers have valid Container Weight declarations. • Delivery requirements do not require or encourage drivers to exceed speed limits, exceed regulated driving hours, fail to meet the minimum regulated driving hours.	• Ensuring goods carried do not exceed vehicle or permitted dimension limits. • Do not cause vehicle or permitted mass limits to be exceeded. • Are appropriately secured.
Consignee/ Receiver	• A consignee has the same duties as the consignor.	• A consignee has the same duties as the consignor.
Scheduler	• Rosters and schedules do not require drivers to exceed the driving hours' regulations or speed limits. • Record keeping of driver's activities, including work and rest times.	

	• Take all reasonable steps to ensure drivers do not work while impaired by fatigue or drive in breach of their work or rest options. • Vehicles regularly maintained. If speed limiters fitted they are functioning properly. • Vehicles are not loaded in a way that exceeds mass or dimension limits. • Drivers moving containers have valid container weight declarations. • Loads are properly restrained with appropriate restraint equipment.	
Manager	• A manager has the same duties as a scheduler. • Must ensure drivers are medically fit to drive.	• Must ensure all loads are properly restrained and do not exceed mass and dimension limits. • Must ensure drivers are medically fit to drive.
Operator	• An operator has the same duties as a scheduler and a driver. • Must ensure drivers are medically fit to drive.	• An operator has the same duties as a manager. • Must ensure drivers are medically fit to drive.
Drivers	• Comply with relevant fatigue management work and rest laws and procedures to implement them. • Make the most of rest breaks by sleeping in dark, quiet and comfortable places. • Respond to changes in circumstances such as delays and report these to the base to implement short-term fatigue management measures. • Ensure vehicle does not exceed mass or dimension limits. • Ensure load is appropriately restrained. • Must ensure they are medically fit to drive. • Ensure vehicles are road worthy and well maintained. • Keep full and accurate records as required by law.	• A driver must ensure that the vehicle does not exceed mass limits. • Ensure vehicle does not exceed dimension limits. • Ensure load is appropriately restrained.

4.3 Findings in Relation to Vertical Integration

Figure 1 shows findings regarding the relationships between the actors of the various levels of the Heavy Vehicle Transport System. Those findings were:

1. Vertical integration between the upper two levels of the Heavy Vehicle Transport System and the lower three levels were not apparent.
2. The system was top level driven with a lack of feedback loops from the lower levels to inform the upper levels who therefore do not attain the necessary information to inform, review and revise strategy and regulations to improve the Heavy Vehicle Transport System.

4.3.3 There was no legislated requirement for a driver, or a heavy vehicle company, to report breaches to the Regulator, whereas this is not the case in other transport modalities such as rail, aviation or mining who are required to report significant breaches (Rail Safety National Law [RSNL], 2015; Transport Safety Investigations Act [TSI Act], 2003; Occupational Safety and Health Act [OSH Act], 1984; and Work Health

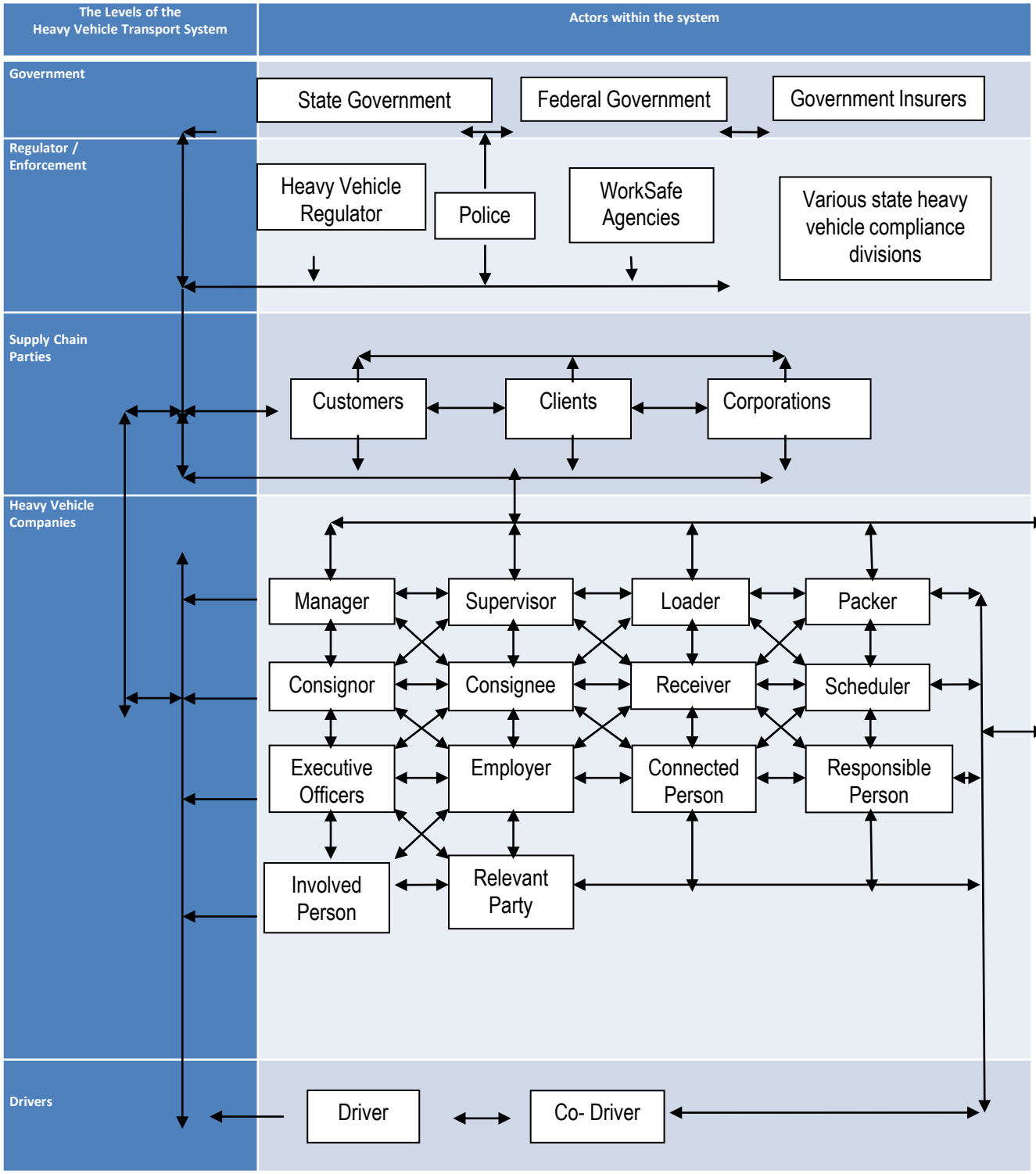
and Safety Act [WHS Act] 2011).

4.3.4 A search of the legislation did not identify an enforceable accountability on the Regulator for breaches that occur within the lower levels of the system where the Regulator has an opportunity to influence or change safety behaviours.

4.3.5 Current information sharing did not identify the system failures that contributed to the breach rather the Chain of Responsibility focuses on the actors that are currently identified in the legislation.

Figure 1

Logic diagram showing the links between the actors of the various levels of the Heavy Vehicle Transport System.



6.0 Discussion

The study identified several strengths and weaknesses within the current Chain of Responsibility legislation in Australia. From a theoretical perspective, the Chain of Responsibility legislation is a good illustration of how safe working practices are intended to operate within a complex socio-technical system (Newnam and Goode, 2015). The study identified the Chain of Responsibility legislation assigns responsibilities to actors across the lower three levels of the Heavy Vehicle Transport System, rather than being driver centric (Scott-Parker et al., 2015). The Chain of Responsibilities' intent is to ensure the blame for a safety breach does not fall on the driver but makes those who are involved with the driver's day-to-day driving activities responsible as well. In other words, the blame for a safety breach can be placed on other actors and hold them accountable for the driver's actions. Multiple parties within the supply chain are identified as being responsible for safety and can be held liable for their actions, inactions or demands that could influence driver behaviour.

The strength in this approach is that the Chain of Responsibility shifts the focus from blaming away from the driver and ensures others in the supply chain who influenced the driver are also held accountable should any breach occur. This risk management approach is similar to other industries, such as rail, where they have legislated the responsibility for safety within the system is a shared. For example, section 50 of the Rail Safety National Law 2012, 'Principles of shared responsibility, accountability and integrated risk management', specifies that the safety of the rail network is a shared responsibility between the rail transport operators, the rail safety workers, other persons, the Regulator and the public. This section clearly defines the actors who have responsibility in ensuring rail safety.

The Heavy Vehicle National Law prescribes a broad range of safety-critical elements including mass, dimension, loading, speed and fatigue, whereas the Compliance and Enforcement regulates a reduced scope of elements limited to mass, dimension and loading. The advantage of the Heavy Vehicle National Law's broad scope is that it ensures there is harmonisation across how the elements are regulated and by whom, and reduces the risk of duplication and inconsistencies across the States where the legislation applies. For example, the Heavy Vehicle National Law has the one Regulator, the National Heavy Vehicle Regulator, who manages the legislation, regulates the actors within the three lower levels of the system and ensures compliance. Whereas in Western Australia there are multiple agencies attempting to enforce the legislation who do not coordinate or communicate effectively to ensure integrity of the Heavy Vehicle Transport System.

Furthermore, the reduced scope within the Compliance and Enforcement legislation, where speeding and fatigue are not legislated, is a weakness. This means that information regarding an actor who is caught speeding or breaching fatigue is not captured under the Western Australian Compliance and Enforcement legislation and is treated under separate legislation. This is further complicated given that speeding and fatigue are regulated by differing regulators; speeding is regulated by Police and fatigue is regulated by WorkSafe Western Australia. In Western Australia, speeding is an offence that is driver centric. That is, the accountabilities for any speeding breach are the sole responsibility of the driver. Whereas under the Heavy Vehicle National Law, if a driver is caught speeding, other actors whose decisions, actions or inactions that have contributed to the driver's speeding behaviour, are also held responsible for that speeding breach. In the case of fatigue, which is superficially regulated in Western Australia under the Occupational Safety and Health Regulations 1996, there are other parties who should be held responsible for a driver committing a fatigue-related offence, but who avoid liability because of the limited scope and application of the legislation. In contrast the Heavy Vehicle National Law captures the element of fatigue in both the Heavy Vehicle National Law Act 2012 and Heavy Vehicle (Fatigue Management) National Regulations 2012 that holds a number of actors responsible for a driver who breaches the fatigue related aspects of the legislation.

This omission within the Compliance and Enforcement legislation is a significant area of weakness as both speed and fatigue are significant contributory factors in safety breaches and crashes (Aliakbari and Moridpoure, 2016; Aliakbari and Moridpoure, 2017; Mooren et al., 2014; Mooren et al., 2015).

A significant finding of this study was that the majority of actors within the system who have responsibilities assigned by the legislation primarily resided within the lower three levels of the Chain of Responsibility, namely the supply chain parties, heavy vehicle companies and drivers. There is limited responsibilities and vertical integration extending up to the Regulator and Government, which highlights that the Chain of Responsibility legislation does not capture the entire Heavy Vehicle Transport System. For example, while the Regulators and Government have obligations to ensure they have systems in place, the legislation is silent on such things as compulsory reporting of incidents and breaches, proactive auditing and surveillance and crash investigations. As a result of this there is very little effective data analysis.

Newnam and Good (2015) identified the need for capturing the complex tapestry of factors influencing road transport crashes. Salmon and Lenne (2015) suggested one of the key barriers preventing systems thinking in road safety was the lack of appropriate systems analysis methods. For example, Police investigations are driver centric and do not consider the influencing actions of other actors in the Heavy Vehicle Transport System. These shortcomings are significant because they lead to inappropriate causation findings that adversely impact upon the lower levels of the Heavy Vehicle Transport System. There is a need to implement a systems analysis method of investigating the cause of incidents so that Government and Regulators can be better informed when determining policy and strategy.

Government should play a critical role in engaging all levels of the system to obtain information that is relevant to policy reform. However, this study identified that the Heavy Vehicle National Law and the Compliance and Enforcement legislation has not included the Government in that role. The Australian Trucking Association has called for the Australian Transport Safety Bureau (ATSB) to take over the responsibility for investigating truck crashes (Kozoil, 2018) but by their own admissions the ATSB currently take 14 months to complete an investigation (ATSB, 2017). This will be a significant negative influence on driving improvement in heavy vehicle transport safety.

The ATSB operates entirely separately from transport regulators, policy makers and service providers (ATSB, 2018). Under existing legislative arrangements, they do not presently investigate heavy vehicle transport crashes; they only investigate aviation, rail and maritime incidents. This is despite the number of yearly deaths in the heavy vehicle transport industry being over triple that of aviation, rail and maritime combined (Safework Australia, 2017; ATSB, 2017). The ATSB has significant powers contained within the Transport Safety Investigation Act (2003) and Regulations (2003) that requires any rail, maritime or aviation organisation to notify them of certain events such as fatalities. Similar powers would benefit heavy vehicle transport safety and learnings from crashes that occur.

In 2012 a Government Senate Committee was set up to inquire into the ATSB in the wake of their investigation into the 'Pel-Air' flight that ditched into the ocean off Norfolk Island. The Committee was scathing (Australian Broadcasting Commission [ABC], 2013) of the investigation and described it to be seriously deficient (Woodley, 2013). Additionally, media coverage of the ATSB's poor performance and lack of resources highlighted the difficulties being experienced by the ATSB in completing its investigations, with only one in three investigations being completed inside the targeted 12-month time frame (ABC, 2017). This supports the ABC's (2017) criticism that the ATSB does not have the capacity and resources to investigated aviation crashes let alone all three transport modalities equally. This draws into question the ATSB's ability to take over investigations into heavy vehicle crashes and questions whether they have the resources, expertise and

capabilities to do heavy vehicle crash investigations.

A review of the ATSB's website into investigations conducted and completed in 2016 – 2018 show there is a primary focus on aviation with limited investigations being conducted into rail and maritime.

The results of this study also act as a starting point to inform international regulatory bodies of the importance in identifying and implementing systems that ensure harmonisation, congruence and vertical integration to minimise risk within the heavy vehicle transport industry. There is similar legislation in New Zealand, Canada and South Africa. However, there is limited Chain of Responsibility legislation elsewhere internationally.

7.0 Conclusions

It is clearly evident that driving heavy vehicles in Australia, as well as in other parts of the world, is a dangerous and deadly occupation. Australia has implemented innovative legislation, albeit two different pieces with the same intent, to make sure that it is not just the driver who is held accountable, or blamed, when a fatality occurs. The 'blame game' does not help identify where the system failed, nor does it help improve the system. It simply takes the focus away from the gaps that lead to incidents occurring. In contrast the Chain of Responsibility legislation ensures system weaknesses are uncovered. However, this study revealed that there is still more room for improvement in the legislation.

This study identified and mapped the actors and their responsibilities within the Heavy Vehicle Transport System to gain an understanding of how the legislation is intended to work as well as identify the factors that influence the actors within the complex socio-technical system that is the Heavy Vehicle Transport System.

There is a need to provide clear responsibilities for all actors identified in the Heavy Vehicle National Law and the Compliance and Enforcement legislation. This study identified differences between the two pieces of legislation, in particular the exclusion of speeding and fatigue from the Compliance and Enforcement legislation. Additionally, this study found there were differences between who regulates and enforces the Heavy Vehicle National Law and the Compliance and Enforcement legislation, as well as differences in the scope between the two. The differences also included the number and type of actors identified within the Heavy Vehicle National Law that is more expansive than that captured in the Compliance and Enforcement legislation.

It would be more effective to have one nationally harmonised law governed by one Regulator with a national reporting and database system. This harmonisation would provide additional opportunities to improve safety within the Heavy Vehicle Transport System through regulated requirements for actors at all levels of the system to become involved. There is currently no national reporting and database system to underpin the effective research and analysis to make informed decisions. A national reporting and database system would capture information that would allow and support Regulators and Legislators to make informed decisions to improve and focus on safety policy and strategy.

This study also revealed opportunities to improve vertical integration within, and across, all levels of the Heavy Vehicle Transport System. The responsibilities of the actors within the Chain of Responsibility were primarily focused at the lower levels of the system, with limited vertical integration to the upper Regulatory and Government levels of the system. The lack of vertical integration between the lower levels of the system and the upper levels, primarily due to their being no compulsory reporting requirement, leaves a significant gap in capturing critical information that can be used to improve the Heavy Vehicle Transport System.

Furthermore, this study identified that a nationally consistent approach to how significant breaches of the Chain of Responsibility legislation are investigated would also assist in improving vertical integration. Although a recommendation has been made for the Government to amend the

legislation that governs the ATSB to include heavy vehicle crash investigations within their scope and charter (Kozoil, 2018), there is some evidence the ATSB does not have the resources, expertise and capabilities to properly undertake investigations into heavy vehicle transport crashes.

Who is responsible? It is clear the legislation imposes obligations on actors beyond the driver and yet in reality the heavy vehicle driver is still the focus of blame.

8. Recommendations

1. Recommendations relating to national amalgamation of legislation

1.To overcome the current weaknesses in the Heavy Vehicle Transport System, the Heavy Vehicle National Law and the Compliance and Enforcement legislation should be amalgamated into a single body of legislation that prescribes and addresses the full spectrum of actors, their responsibilities, all of the Chain of Responsibility elements, and be enforced nationally by the one national Regulator.

2.Include in the amalgamated legislation a requirement for all actors in the heavy vehicle industry to report serious breaches, incidents and crashes.

3.Develop and implement a heavy vehicle 'list of incidents' to inform the heavy vehicle industry of what incidents, breaches and crashes must be reported. Use the Rail Safety National Law and Work Health Safety Act framework as guides to develop a usable document (RSNL, 2015; OSH Act, 1984; WHS Act, 2011).

8.2 Recommendations relating to the implementation of an independent national heavy vehicle transport investigation agency.

1.Implement an Independent National Heavy Vehicle Transport Investigation Agency that has the same powers and authorities of the ATSB, Police and WorkSafe, to conduct investigations into heavy vehicle crashes.

2.Implement a national investigative process with standardised methods so that all heavy vehicle crashes are investigated in the same manner, irrespective of who conductsthe investigation and where the incident occurs, to guarantee continuity and quality outcomes.

8.2.3 Implement a national information database that captures, collates and provides information from heavy vehicle transport incidents so that the results can be analysed and information can be shared within the Heavy Vehicle Transport System to inform policy, strategy development and improve safety decision making at all levels of the Heavy Vehicle Transport System and help deliver a step change in heavy vehicle transport safety.

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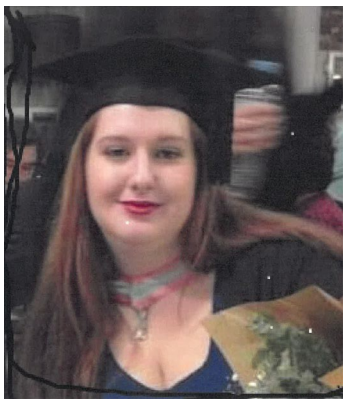
Associate Professor Yvonne Toft is an Associate Professor in Human Factors and Systems Safety in the Transport and Safety Sciences group at CQUniversity, Australia. Yvonne currently teaches and conducts research in areas related to human factors engineering, occupational health and safety, accident forensics and investigation, operational systems safety and technology in public safety, in industrial and transport related contexts. Yvonne has a long history of active involvement and leadership in multiple professional associations nationally and internationally spanning safety, engineering, human factors, learning and teaching. Specialties: reduction of design-induced end user error sources in original engineering design, accident analysis, prediction of error sources, systems safety, transdisciplinary communication and design, professional communities of practice, innovation of curriculum design in flexible learning

Dr Geoff Dell is an Adjunct Professor at Federation University and former Head of Safety Science Courses at Central Queensland University. He is a career Safety Scientist with 40 years of senior safety management roles in aviation, rail and other industries. Dr Dell was National President of the Safety Institute of Australia for 9 years and the Independent Safety Adviser and Member of the Board of Directors of Cobham Aviation Services, the third largest airline in Australia, and was the independent Chairman of the Board Safety Sub-committee of Nauru Airlines for 2 years. In 2010 he joined CQUniversity to develop and implement the world first tertiary education courses in accident investigation including the unique Bachelor of Accident Forensics and the Master of Accident Investigation with majors in air safety investigation, rail safety investigation, road safety investigation, occupational safety investigation, risk engineering and human factors engineering. This work included the development of the world's first genuine multi-modal forensic investigation teaching laboratory (Crash Lab). In addition to aviation, rail and road crashes, Dr Dell has led major investigations in many other industries, including mining where he was commissioned by the Western Australian Government to conduct the independent Section 45b investigation into the fatal explosion at Boodarie Iron, Port Hedland in 2004. He has over 40 papers published in peer reviewed and refereed journals, has presented over 100 invited papers at safety conferences globally and is sought after by the media in Australia and overseas as a commentator on aviation and other crashes, including MH370, MH17, German Wings 9525, Air ASIA 8501 and more recently the Lion Air and Egypt Air B737 Max crashes.



Shevaun Dell is an accident forensics educator who is passionate about improving the quality and transparency of the communication of research and scientific findings to the broader community. Trained in forensic science, psychology and criminology, she has taught at Centrel Queensland University for over four years and been involved in a variety of safety science research projects ranging from transport domain accident investigations to workplace bullying and stress. She is currently completing a forensic psychology-related PhD research study.

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World Safety Organization (WSO)

The WSO was founded in 1975 in Manila, The Republic of the Philippines, as a result of a gathering of over 1,000 representatives of safety professionals from all continents at the First World Safety and Accident Prevention Congress. The WSO World Management Center was established in the United States of America in 1985 to be responsible for all WSO activities, the liaison with the United Nations, the co-operation with numerous Safety Councils, professional safety/environmental (and allied areas) organizations, WSO International Chapters/Offices, Member Corporations, companies, groups, societies, etc. The WSO is a not-for-profit corporation, non-sectarian, non-political movement to ***"Make Safety a Way of Life… Worldwide."***

World Safety Organization Activities

WSO publishes WSO Newsletters, World Safety Journal, and WSO Conference Proceedings.

WSO provides a network program linking various areas of professional expertise needed in today's international community.

WSO develops and accredits educational programs essential to national and international safety and establishes centers to support these programs.

WSO receives proposals from professional safety groups/ societies for review and, if applicable, submits them to the United Nations for adoption.

WSO presents annual awards: The James K. Williams Award, Glenn E. Hudson International Award, J. Peter Cunliffe Transportation Award, Concerned Citizen, Concerned Professional, Company/Corporation, Concerned Organization, Educational Award, WSO Chapter/National Office of the Year, and Award for Achievement in Scientific Research and Development.

Concerned

WSO provides recognition for safety publications, films, videos, and other training and media materials that meet the WSO required educational standards.

WSO establishes and supports divisions and committees to assist members in maintaining and updating their professional qualifications and expertise.

WSO has Chapters and National/International Offices located throughout the world, providing contact with local communities, educational institutions, and industrial entities.

The WSO organizes and provides professional support for international and national groups of experts on all continents who are available to provide expertise and immediate help in times of emergencies.

Benefits of Membership

WSO publishes the "WSO Consultants Directory" as a service to its Members and to the Professional Community. Only Certified Members may be listed.

WSO collects data on the professional skills, expertise, and experience of its Members in the WSO Expertise Bank for a reference when a request is received for professional expertise, skill, or experience.

WSO provides a network system to its Members whereby professional assistance may be requested by an individual, organization, state, or country or a personal basis. Members needing assistance may write to the WSO with a specific request, and the WSO, through its

Membership and other professional resources, will try to link the requester with a person, organization, or other resource that may be of assistance.

WSO provides all Members with a Membership Certificate for display on their office wall and with a WSO Membership Identification Card. The WSO awards a Certificate of Honorary Membership to the corporations, companies, and other entities paying the WSO Membership and/or WSO Certification fees for their employees.

Members have access to WSO Newsletters and other membership publications of the WSO on the WSO website, and may request hard copies by contacting the WSO World Management Center. Subscription fees apply to certain publications.

Members are entitled to reduced fees at seminars, conferences, and classes given by the WSO. This includes local, regional, and international programs. When Continuing Education Units (CEUs) are applicable, an appropriate certificate is issued.

Members who attend conferences, seminars, and classes receive a Certificate of Attendance from the WSO. For individuals attending courses sponsored by the WSO, a Certificate of Completion is issued upon completion of each course.

Members receive special hotel rates when attending safety programs, conferences, etc., sponsored by the WSO.

Membership

The World Safety Organization has members who are full time professionals, executives, directors, etc., working in the safety and accident prevention fields, including university professors, private consultants, expert witnesses, researchers, safety managers, directors of training, etc. They are employees of multi- national corporations, local industries, private enterprises, governments, and educational institutions. Membership in the World Safety Organization is open to all individuals and entities involved in the safety and accident prevention field, regardless of race, color, creed, ideology, religion, social status, sex, or political beliefs.

Membership Categories

Associate Membership: Individuals connected with safety and accident prevention in their work or individuals interested in the safety field, including students, interested citizens, etc.

Affiliate Membership: Safety, hazard, risk, loss, and accident prevention practitioners working as full time practitioners in the safety field. Only Affiliate Members are eligible for the WSO Certification and Registration Programs. **Institutional Membership**: Organizations, corporations, agencies, and other entities directly or indirectly involved in safety activities and other related fields. **Sustaining/Corporate Member**: Individuals, companies, corporations, organizations or other entities and selected groups, interested in the international effort to "***Make Safety A Way Of Life...Worldwide***."

The WSO Membership Application is included on the following pages and is also available on the WSO website:
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World Safety Organization

Code of Ethics

Members of the WSO,
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are bound to the following Code of Ethics regarding their activities associated with the WSO:

Members must be responsible for ethical and professional conduct in relationships with clients, employers, associates, and the public.

Members must be responsible for professional competence in performance of all their professional activities.

Members must be responsible for the protection of professional interest, reputation, and good name of any deserving WSO member or member of other professional organization involved in safety or associate disciplines.

Members must be dedicated to professional development of new members in the safety profession and associated disciplines.

Members must be responsible for their complete sincerity in professional service to the world.

Members must be responsible for continuing improvement and development of professional competencies in safety and associated disciplines.

Members must be responsible for their professional efforts to support the WSO motto:

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