Exploring the Causes of Port Accidents: A Case Study of Kaohsiung Port, Taiwan

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Abstract: Port accidents, such as collisions and explosions, may cause loss of life, serious injury, and economic loss and damage. Using a grounded theory approach, this paper takes Kaohsiung port as a case to explore the causes of port accidents. In addition to gathering data from the literature, qualitative in-depth interviews were conducted with 7 terminal operators and 7 port officials regarding the incidence of accidents of the workers exposed to risk in the area, to ensure that the present knowledge base was covered. Results summarise four findings that interviewees felt key in causing any accidents: human physical and psychological situation, ship/shore-side equipment and management, accident reporting and response mechanism, and safety training and maritime traffic rules. These findings are intended to help enable managerial solutions for risk situation identification, port safety improvement and environment damage reduction, and also to provide a basis for further research to help improve port safety.

Keywords: Port, Accident, Kaohsiung

1. INTRODUCTION

Ports are the interface of many different maritime transportation modes. Yet, port operations often entail numerous potential risks and related hazards such as oil spills, collisions, grounding, truck accidents, injuries and personnel going overboard. Such accidents have adverse (and possibly seriously adverse) impacts on the environment, health, and also on company viability through financial loss and increased insurance. It is generally accepted that human factors play a fundamental role in port safety (Reason, 1990; Wiegmann and Shappell, 2003; Fabiano et al., 2010) since many crew's physical or psychological situation can influence the occurrence of port accidents and consequently bring personnel injury/death, as well as environmental damage. Potentially dangerous conditions and factors include fatigue, carelessness, stress, health, situation awareness, mistakes, inadequate training, and safety

culture (Hetherington et al., 2006; Lu and Tasi, 2008; Tzannatos and Kolotos, 2009). In general, increased vessel traffic and cargo loading/unload can lead to port casualties occurring more often in the light of increased port activities and higher operation frequencies.

Taiwan is highly dependent on foreign trade. In terms of total volumes, measured by weight-ton, sea shipments are responsible for more than 99% of Taiwan's total international trade (Transportation Research Statistics, 2014). Taiwan has moreover become a pivotal point for shipping lines crossing the Pacific Ocean and, as a consequence, has developed three main international ports, with Kaohsiung port being the gateway city of Taiwan. In addition, due to its geographical location, Kaohsiung port has become a center of multinational operations and a shipping hub with a significant amount of transshipment traffic to and from many countries. In 2014, there were 34,593 ship movements in Kaohsiung port, and thus constant vigilance for port operators is essential to help ensure safe operation. In recent years, nevertheless, port accidents have continued to occur in Kaohsiung port. For example, oil spills have happened in a cargo ship when refueling due to the fuel pipe being dropped in 2012 (NOWnews, 2012). Table 1 shows the publically available statistics fatalities/injuries and ship damage in the Port of Kaohsiung during 2013-2014.

Table 1. Fatalities/injuries and ship damage statistics in Kaohsiung port

Year	Fatalities and injuries	Ship damage
2013	1	21
2014	0	4
Total	1	25

Source: Ministry of Transportation and Communication http://www.motc.gov.tw/en/index.jsp

Table 2 illustrates the distribution of accident types. Collision/contact accounts for 41.3% of all accidents within Kaohsiung port. The main collision/contact and machinery failure are human carelessness and inadequate maintenance. When the causes are unknown, they are categorized into other types. In sum, human carelessness is the main cause in these accidents.

Table 2. Accident type statistics in Kaohsiung port

Year	Total	Collision/ Contact	Stranding/ grounding	Fire	Explosion	Loss of containment	Capsized/ list	Machinery failure	Others
2010	80	39	9	3	0	0	0	25	4
2011	104	28	8	7	3	0	2	39	17
2012	70	25	5	1	1	2	2	7	27
2013	30	18	2	1	0	0	0	2	7
2014	21	19	0	0	0	2	0	1	1
Total	305	129	24	12	4	4	4	74	56
%		42.2	7.8	3.9	1.3	1.3	1.3	24.2	18.3

Source: Ministry of Transportation and Communication http://www.motc.gov.tw/en/index.jsp

Critically, an understanding of individuals' perceptions of the term 'risk' can help port authorities, shipping operators, and also the field be more aware of how individuals will react in certain circumstances. In ports, it may be the case that temporary employment conditions,

less experience amongst workers, and downsizing (Fabiano et al., 2010) may be placing more strain on workers. Thus, any attempts to understand what others believe ‘risk’ to involve are critically important as their understandings of what actions constitute ‘risk’ will be inextricably linked to many of the decisions they make. Further, individual perceptions of words and concepts are inextricably linked with culture and experience and context (Voloshinov, 1973; Richards and Pilcher, 2013) and to thus explore ‘risk’ and port safety from an in-depth perspective will help shed light on how such concepts are understood.

In this paper, based on grounded theory, the individual perception of ‘risk’ was adopted as a focus to explore potential port accidents. Although many categorizations of ‘risk’ have been highlighted, for example, in terms of fatality risks, health risks, property risks, economic risks and environmental risks (Vanem, 2012), actual employee perceptions of what constitutes risk have seldom been investigated in the port. Thus, an examination of how such risk perception is linked with port accident is important in an attempt to help improve port safety. The rest of this paper is organized as follows. Section 2 reviews past literature. Section 3 outlines and explains the methodology. The results are then presented and analyzed in section 4. Finally, conclusions, including suggestions for further research in the field, are given.

2. LITERATURE REVIEW

The Maritime Safety Committee of the International Maritime Organization (IMO) has asked its members to adopt Formal Safety Assessment (FSA) and International Convention for the Safety of Life at Sea (SOLAS) to help improve ship safety and reduce accidents. The field of risk management, accident awareness and health and safety is a much researched area and many aspects have been studied. One area is that of in-depth post-accident analysis. This has been the subject of research that has focused on one particular accident (e.g. Stoop, 1995) in difficult driving conditions in Breda, The Netherlands. Other research has analysed how accident analysis is done in a particular company (e.g. Goh et al., 2012) and then integrated in the training for that particular, in this case, mining, company. Such work has also focused on a particular area and a particular ‘industry’. For example, Patwary et al (2012) considered the role of ‘fatality’ in managers’ and employees’ interpretations of occupational accidents in the medical field. More generic post-accident research has also been conducted (e.g. Roed-Larsen and Stoop, 2012) through a SWOT analysis to identify generic factors for all companies to focus on in health and safety.

A historical focus has also been adopted through the study of port safety in Genoa, Italy (Fabiano et al., 2010). Specifically, Fabiano et al (2010) found that safety had not increased with the container revolution and that in Genoa at least, for various reasons highlighting the complexity of the issue (see below), “the box that changed the world has not improved safety

conditions in port activities." (Fabiano et al., 2010, p. 989). Other work has focused on perceptions of the 'Human Factor' or HF (Teperi and Leppänen, 2011). Significantly, this research found that the 21 managers interviewed, "were found to have disjointed and vague conceptions of HF and a lack of shared vision or strategy regarding HF. Some managers lacked an appropriate conception of HF" (Teperi and Leppänen, 2011, p. 438). Not only was there such a wide variety of perceptions with regard to the Human Factor, but, notably, as correctly asserted by Teperi and Leppänen, (2011, p 438): "In dynamic complex systems such as aviation, shipping and nuclear power, human contribution has been recognized as a root factor in 80-90% of accidents and incidents (Reason, 1990; Wiegmann and Shappell, 2003)." Thus, clearly, "the mastery of human factors… is necessary when implementing safety management in complex systems" (Teperi and Leppänen, 2011, p. 438).

In terms of the complexity involved with researching safety and risk, the area is, unsurprisingly, extremely complex. With regard to post-accident analysis, Roed-Larsen and Stoop (2012) note a number of key areas. They note the increase in external influences such as legalistic approaches; they note the rapid development in information skills and domain specific qualifications leading to a higher need for investigative skills and domain specific qualifications; they note that the need for collective learning means safety investigations should be seen as national rather than local phenomena and; they note the need for agencies to oversee safety investigations given moves toward the privatization of such roles (Roed-Larsen and Stoop, 2012, p. 1396). Earlier research by Stoop into post-accident analysis of a single road accident also shows the complexity involved, and that in the case of road accidents, these can be caused by several factors (e.g. Stoop, 1995), some of which could be at higher levels of systems than the driver in road accidents, and Stoop (1995) rightly highlights the fact that a lack of driver training for fog driving contributed to a major accident in Breda.

Indeed, other research underlines this shift from a 'blame the victims' approach to one whereby management systems and the processes adopted contribute to accidents (Flin et al., 2000; Fernandez-Muniz et al., 2009) and emphasizes the importance of having a safety culture (e.g. Goh et al., 2012). The importance of culture is also shown by the attribution of occupational accidents in the medical arena in Bangladesh to the concept of 'fatality' (Patwary et al., 2012). Patwary et al's (2012) research shows the importance of such an attribution by both managers and employees to fatalism as a cause of accidents means that, "a lack of organizational awareness…can occur within a culture of fatalism." (Patwary et al, 2012, p.76). Extending this complexity, Patwary et al (2012) note that such a culture of fatalism can stem from a range of factors: "It may arise from general cultural influences (or perhaps the more specific influence of their employers), it may be a feature of their helplessness in the face of risk, or they may use fatalism to explain to themselves their lowly

position in society. While all may have a role, it is difficult to be sure of their relative importance" (Patwary et al., 2012, p. 80). Such an approach to fatality resonates in other research as well. For example Teperi and Leppänen (2011) found that with responsibility for implementing human factor training, many upper management were, "in actual fact… waiting for it to come from somewhere else in the organization" (Teperi and Leppänen, 2011, p. 446).

With regards to methodology and methods, there have been many approaches to study this area, commonly quantitative, but also qualitative. A number of studies have used visual methods to create systems analyses (e.g. Goh et al., 2012) or graphic representations of accidents (e.g. Svedung and Rasmussen, 2002), and noted that as well as proving extremely useful in representing the data, that "the graphics have been very useful as 'conversation pieces' during interviews" (Svedung and Rasmussen, 2002, p. 403). Visually, quantitative incident tree analysis is also done (Wang et al., 2010) and a number of studies detail the importance of such visual representations as they help with providing feedback structures "by expressing problems systematically (MoreCroft, 2007)" (Goh et al., 2012, p. 118), something which has proven particularly useful in changing company culture. Park et al. (2015) used fuzzy analytical hierarchy process to rank the safety factors of the targeted ports in Korea from a captain's perspective. Other methods used are interviews, although these tend to be more survey type rather than in-depth interviews (e.g. Svedung and Rasmussen, 2002; Lu and Tseng, 2012). Nevertheless, for Teperi and Leppänen (2011) even though structured interviews were done with 34 questions, qualitative data was also gained, and this was of value as the "Qualitative data… helped to form proposals to implement HF in other high-reliability organizations in the future." (Teperi and Leppänen, 2011, p 446). Based on grounded theory, Mullai and Paulsson (2011) used structural equation modeling to investigate marine accidents. The results found ship's properties and number of people on board are main factors that affect fatality. In road transportation, Carreira et al. (2013) used grounded theory to interview 49 bus passengers' travel experience in two types of mid-distance. Similarly, other work details surveys as the main tool but again cites the data as being qualitative (e.g. Falafiou et al., 2006) which is surprising given the fact that such methods are often considered quantitative by qualitative researchers (Cresswell, 2003). Despite this, there are also studies that have employed in-depth interviews to gain rich access into individuals' perceptions of accidents and their causes (e.g. Patwary et al., 2012), and it is this approach, within the framework of a constructivist grounded theory approach, that is adopted here. Indeed, with regard to surveys and questionnaires, although these provide a broad range of data and allow access to many views, they ignore the essentially social nature of language (Voloshinov, 1973) and do not allow for dialogue (Bakhtin, 1981). This can often bias results through resistance on the part of participants to complete the questionnaires accurately (Galasiński and Kozłowska, 2010). In contrast, in-depth interviews, although not allowing access to as many

participants for logistical reasons, allow for further dialogical exploration of perceptions, and as a result they are the method chosen here.

3. METHODOLOGY

The reality of how port accidents occur can be highly complex and attributable to a range of factors. Many papers published in this area have adopted quantitative methodologies (e.g. Yip, 2008; Debnath and Chin, 2009; Chin and Debnath, 2009; Lu and Tsai, 2008; Lu and Yang, 2010; Hsu, 2012), but the ability of qualitative methodologies to gather in-depth views has been largely overlooked to date. Based on grounded theory, such interviews can complement quantitative studies by providing in-depth views of key stakeholders and thus affords access to their wealth of knowledge and experience. Although a range of qualitative approaches could be chosen as a form of analysis such as content analysis, narrative analysis or discourse analysis, we consider grounded theory the most appropriate approach in this case. In particular we adopt a constructivist grounded theory (Charmaz, 2011) as this allows us to analyse the interview data through looking for emergent themes rather than draft themes on to the data. In this was we allow the data to inform us of the key themes rather than seek to find our own key themes in the data. This way we considered more valid and more useful in this specific case where we were unsure as to what specific themes would arise of importance.

To do this, the methodology for the paper adopted in-depth semi-structured interviews with terminal operators and governmental officials in Kaohsiung port. Interviews in face-to-face meetings at their working sites were conducted during November to December 2014. The interviewees were selected based on their background (e.g. operation department of terminal or labor safety and health management department) and involvement in the topic being researched. For this paper terminal operators (8) with an average of 15 years' experience, ranging from 10 to 20 years, were interviewed, and their job types included president, senior director, junior vice president, and senior onshore manager. Also interviewed were government officials (5) averaging 16 years' experience, ranging from 10 to 25, and their job types included director, senior deputy director, and supervisor.

Each interview lasted on average 30-45 minutes. Ethical approval for these interviews was sought from the appropriate bodies and all participants' anonymity was assured (Christians, 2011). The experts were asked about potential risks that might be involved with the relevant port accident issues. The outlines for interviewees included: what are the main causes of port accident? How likely is that to happen? How do you feel? What can be done and what options are available to mitigate these accidents? Interviews were recorded, transcribed, coded, and then analyzed using a constructivist grounded theory approach (Charmaz, 2011) whereby themes emerged through analysis so they could be categorized appropriately rather than

approaching the data with a predetermined code as would be the case in a more objectivist grounded theory (Charmaz, 2011).

4. RESULTS

The main research findings are summarized into the following four areas:

4.1 Human Physical and Psychological Situation

In practice, port operators needed to work long shifts very often and such work patterns were felt to possibly result in poor work performance due to fatigue. Lengthy working hours and pressure lead to workers having a diminished efficacy of decision-making abilities when they were on duty. Performance impairment was said to include an inability to concentrate, poor memory, slow response, potential loss of control of physical movements, and mood and attitude change. Consequently, the possibility of accidents through the occurrence of such factors as these would be increased. In addition, it was felt that port operators who overly relied on maritime facilities or were overconfident may lead to risky collision situations. In sum, these human errors were felt to come from slips, lapses, mistakes and violations.

4.2 Ship/Shore-side Equipment and Management

Ship/shore-side equipment was noted to consist of automatic identification system (AIS), vessel traffic center (VTC), steering gears, windlasses, and so on. Communication using this equipment was said to have to involve cooperation between related stakeholders such as port authorities, ship masters and owners, pilot(s), berth operators, coast guards, and others. However, it was stressed that safety management may not be conducted well due to conflicting interests. It was felt that regular safety inspection using a checklist should be implemented, linked with supervision mechanism, especially in dangerous working areas (such as oil or chemical product) in Port State Control (PSC). In Taiwan, typhoons often bring heavy rain and strong winds during summer. Weather forecasting information should be announced to port authorities to help them prepare against natural calamity in advance, such as by securing ships, cargo stowage, and terminal equipment. Also, the efficiency of rescue actions was felt to be important (e.g. 72 hours critical search rescue period) and that to achieve this necessitated effective cooperation between public and private sections.

4.3 Accident Reporting and Response Mechanism

In some companies, it was felt that punitive policies could affect openness and discourage crews from expressing unclear doubts, and further hide potential causes that could in turn lead to a disaster. Therefore, it was stressed that managers should encourage employees to deliver clear information and confirm its reception by giving effective feedback, and all this should take place without fear of retribution. It was felt that if an accident happens, it should be fully recorded and detailed on a database and its causes fully explored to avoid future similar

situations. However, it was also noted that in some cases, some accident records are not revealed as they involve business secrets, reputation and litigation issues. Thus, gaining a full picture is often not possible to do for researchers.

4.4 Safety Training and Maritime Traffic Rules

It was noted that a crew's professional skills (e.g. risk identification and response procedure), work attitude and safety culture would affect port safety performance. In addition, language and communication ability with crews was one of the determinants of the port accident (Hetherington et al., 2006). For example, it was felt that marine pilots must effectively communicate from the shore-side tower to ensure the safe navigation of vessels. Further, in Kaohsiung port, participants noted that fishing boats sometimes violated the marine traffic rules by entering the fairway improperly due to the fact that it made fishing operations more convenient. Such behavior would endanger inbound and outbound vessels. In particular, it was noted that sometimes, small fishing boats may not be easily seen by huge vessel and consequently result in collision incident.

4.5 Summary

In sum, the findings from the interviews showed that there is a need to establish guidelines with regard to safety risk perception and culture for each port operator within the range of port operations. It was felt that information must be clearly transmitted and its communication confirmed through standard operation procedures and regulation policy. Further, effective and regular supervisions were considered to be necessary procedures to help minimize potential risks and accidents in the port area. Finally, based on above four aspects, we summarise the comparison on the perception differences between the port operators and government officers in Table 3.

Table 3 Comparisons of Perception between port operators and government officers

	Port operators	Government officers
Human Physical and Psychological Situation	High work pressure and paper work burden means they can not concentrate on safety management work.	Human factors are complicated and are not easy to control. High risk ships are viewed as a priority to check.
Ship/Shore-side Equipment and Management	Operators are concerned with equipment cost and operation efficiency.	Besides VCT control, effective security work must cooperate with police department in order to check potential risky areas. Due to the lack of manpower, video cameras are widely adopted in the port areas.
Accident Reporting and Response Mechanism	Operators felt it would be useful to help encourage an appropriate blame-free forum for the reporting of accidents since they can involve litigation, insurance and impact on company reputation	Officers will report accident issues and announce them to other organisations, such as the Port of Kaohsiung Taiwan International Ports Corporation, Coast Guard Administration, Kaohsiung Harbor Police Department, Marine Bureau (Kaohsiung City Government), Environmental Protection Bureau (Kaohsiung City Government)
Safety Training and Maritime Traffic Rules	Fit the threshold of safety training and international rule	Based on PSC rule, officers regularly check necessary document

5. CONCLUSION AND DISCUSSION

A decrease in port accident leads to fewer workplace disruptions and help improve operational efficiency. Yet, as the continuing number of accidents from Kaohsiung Port over the five years from 2010 to 2014 shows, it is essential to continually study and monitor perceptions and approaches to risk and safety. The results presented in this paper reveal what key stakeholder perceived the major causes that affect port accidents to be. We argue that the use of this method revealed in-depth elements that help to complement existing quantitative data. Based on in-depth interviews, these results reflect the value of exploring potential risk situations and understanding the necessary safety management works in the port area. The contribution of this paper complement the past quantitative based literature and specific safety type survey (e.g. Lu and Tasi, 2008; Lu and Yang, 2010; Fabiano et al. 2010). Two groups (port operators and government officers) are interviewed in this paper to help understand and compare their safety perception differences. This qualitative analysis fundamentally helps

understand the causes and future improvement methods in various types of accidents through an in-depth perspective. Four main research findings were summarized and discussed: human physical and psychological situation, ship/shore-side equipment and management, accident reporting and response mechanism, and safety training and maritime traffic rules. Fundamentally, participants felt that port accidents would involve a combination of human, technological and organizational factors. Also, natural disasters (e.g. bad weather with huge rain) could bring heavy loss of the port due to accidents. Therefore, risk assessment regarding port operations should be more emphasized for port authorities in order to improve navigation safety for ships in ports. Further, safety management requires both commitment and compliance with the maritime rules, and the fostering of a no-blame culture of accountability and open and complete reporting. Each port worker should proactively be aware of potential risk issues in the port area and form an effective safety culture or safety climate in the organization. The research findings from this case study of Kaohsiung port complement the literature in the field as well as aim to improve port safety in order to prevent accidents, help save lives, money and environmental costs. It is expected that these will be further used regionally at first but later globally, and it is hoped that such results as here can be complemented by further similar studies in other ports. Given the fact that the increase in volume of trade and ship calls is set to continue the issue of health and safety is an ever present and ever-significant one that requires continual vigilance and study.

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