

Fatal and serious injuries on board merchant cargo ships

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ABSTRACT

Background: Merchant seafaring is one of the most dangerous occupations in the world which hosts the physical, ergonomic, chemical, biological, psychological and social elements, which could lead to occupational accidents, injuries and diseases. Therefore, it is a field that should be studied meticulously and frequently. The aim of this study is to investigate the frequency, circumstances, and causes of occupational accidents on board merchant cargo ships and to identify the risk factors during the daily routine works and dangerous works to be fulfilled.

Materials and methods: Data used in this study obtained various occupational accident reports issued by countries' accident investigation units or maritime authorities such as Marine Accident Investigation Branch (MAIB), Marine Safety Investigation Unit (MSIU) and Australian Transport Safety Bureau (ATSB). A total of 331 reports met the inclusion criteria for the 11-year period from 2006 to 2016. Descriptive statistics were given related to data and chi-square analysis was used to test for significant association between categorical variables (seafarer's age, accident type and etc.) and injury severity.

Results: Several findings were notable in this study. Ratings (63.5%) were the most affected group suffered from occupational injuries among the crew and the most critical cause of occupational accidents was found the dangerous work practices and ignorance of rules and instructions.

Conclusions: Occupational accidents are still a crucial concern in the maritime industry which imposes a major burden on both seafarers and shipping companies. Reduction in occupational injuries could be achieved by improving the working environment and the quality of life on board, mitigating the mental and physical burden of work and developing policies to encourage the seafarers to obey safety rules and instructions.

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Key words: injury severity, seafarers, merchant cargo ships, occupational risks

INTRODUCTION

Merchant seafarers work in a perilous environment which comprises the physical, ergonomic, chemical, biological, psychological and social elements which could lead to occupational accidents, injuries and diseases [1]. As a result of this dangerous environment, merchant seafarers are exposed to extreme weather conditions [2, 3], hazardous enclosed spaces, noisy mechanical equipment and toxic cargoes [4]. Furthermore, because of the nature of the maritime profession, seafarers face stringent working conditions such as isolation from everyday life, long hours of work, rigid organisational structures and high levels of stress and fatigue [1].

Merchant shipping has, in some countries, fatality rates which are more than 20 times that of the average of the respective country's shore-based industries [5]. According to a study of Saarni [6] which comprises Finnish seafarers, the rate of occupational accidents was found close to the rate of for the whole working population in terms of non-fatal injuries. However, there is a lack of statistics in the area of maritime occupational safety and health because of the poor recording and significant differences in data collection methodologies of occupational accidents, incidents and diseases in flag States [1]. Especially, near-accidents, or accidents not causing loss of work-time or sick-leave, are seldom reported from ships [7].

The aim of this study is to investigate the frequency, circumstances, and causes of occupational accidents on board merchant cargo ships and to identify the risks factors during the daily routine works and dangerous works to be fulfilled. After analysing the main causes and risk factors of the occupational accidents clearly that would be easier to take correct preventive measures.

MATERIALS AND METHODS

Data used in this study obtained various occupational accident reports issued by countries' accident investigation units or maritime authorities such as Marine Accident Investigation Branch (MAIB), Marine Safety Investigation Unit (MSIU) and Australian Transport Safety Bureau (ATSB). Table 1 shows the number of occupational accident reports obtained from each investigation unit or maritime authority. Reports concerning occupational accidents occurred on board merchant cargo ships that has over 500 gross registered tons and over included in this study. Fishing vessels and passenger ships were excluded due to these vessels require quite different work experiences in terms of technical demands [8]. Also, reports related to non-crew members such as passengers, pilots, cargo inspectors and dock workers were left out of scope for this study. A total of 331 reports met the inclusion criteria for the 11-year period from 2006 to 2016. Hong Kong, Malta, Denmark, Germany, Australia and United Kingdom provided 80% of the all accident reports used in this study.

Accidents reports were examined through content analysis in the light of the variables obtained from the literature. Then, variables were divided into three categories as seafarer-related variables, ship-related variables and accident-related variables. Ship-related variables included ship age and ship type. Accident-related variables included occupational accident type, working situation at time of the accident and cause of accident. And, the variables related to the seafarer included seafarer age, experience, rank and time on board spent by seafarer when accident took place. Seafarer ranks were classified as officers and ratings and service crew were included also to ratings category because of scarce reports concerning service crew. Injury severity which grouped into serious injuries and fatal injuries were used as dependent variable to be able to carry out significance tests. According to International Maritime Organisation (IMO) [9], a very serious marine casualty means a marine casualty involving the total loss of the ship or death or severe damage to the environment. A serious injury means an injury sustained by a seafarer, resulting in incapacitation where the seafarer is unable to function normally for more than 72 hours, commencing within 7 days from the data when the injury was suffered. In the light of these definitions, very serious marine casualties which resulted in death of seafarers were

Table 1. Number of occupational accident reports according to preparatory Accident Investigation Unit

Investigation Unit	Country	Number of reports
MARDEP	Hong Kong	77
MSIU	Malta	56
BSU	Germany	40
MAIB	England	36
ATSB	Australia	32
DMAIB	Denmark	24
JTSB	Japan	14
DSB	Holland	10
AIBN	Norway	9
HBMCI	Greece	7
IMMA	Isle of Men	7
SIA	Finland	7
BEAMER	France	3
TAIC	New Zealand	3
TSBC	Canada	3
TBMA	Bahamas	2
PKBWM	Poland	1
Total		331

accepted as fatal injury. Besides, any fracture, any loss of a limb or part of a limb, loss of sight, whether temporary or permanent and any other injury leading to hypothermia or unconsciousness etc. and slight injuries were evaluated in the context of serious injury.

An occupational accident type means the mode in which a seafarer on board injured. In this context, accident not related to ship operations, illness, suicide and homicide can be regarded as occupational accident type [10]. Some studies which examined occupational mortality at sea [4, 11–16] divided cause of deaths into two categories as deaths from disease and deaths from external causes. Deaths from external causes comprised of accidents, suicide, homicide and unknown circumstances. And accidents which caused deaths at sea examined under three headings as maritime disasters, occupational accidents and off-duty accidents. However, occupational accident types were not used in the analysis or accident type included to study as the cause of accident in the aforementioned studies. Unlike these studies, only included occupational accidents occurred on board ship, while homicide, suicide and maritime disaster caused to death or injury excluded in this study. And, the occupational accidents were classified according to International Labour Organisation (ILO) [17] in terms of accident type (e.g., falls of persons, struck by falling objects and exposure to or contact with harmful substances).

Table 2. Distribution of injuries according to seafarer characteristics

Seafarer's	All cases	Injury severity	
		Serious injury	Fatal injury
Age at time of accident [year]			
≤ 25	30 (9.0%)	12 (40.0%)	18 (60.0%)
26–35	106 (32.0%)	39 (36.8%)	67 (63.2%)
36–45	88 (26.5%)	35 (39.8%)	53 (60.2%)
46–55	60 (18.1%)	19 (31.7%)	41 (68.3%)
≥ 56	47 (14.1%)	16 (34.0%)	31 (66.0%)
Sea experience [year]			
≤ 5	99 (30.0%)	37 (37.4%)	62 (62.6%)
6–10	85 (25.6%)	32 (37.6%)	53 (62.4%)
11–15	50 (15.1%)	24 (48.0%)	26 (52.0%)
16–20	39 (11.7%)	9 (23.1%)	30 (76.9%)
21–25	30 (9.0%)	10 (33.3%)	20 (66.7%)
≥ 26	28 (8.4%)	9 (32.1%)	19 (67.9%)
Time aboard when accident took place [month]			
≤ 3	148 (44.7%)	57 (38.5%)	91 (61.5%)
4–6	140 (42.2%)	53 (37.9%)	87 (62.1%)
7–9	43 (13.0%)	11 (25.6%)	32 (75.4%)
Occupation on board*			
Officers	121 (36.5%)	53 (43.8%)	68 (56.2%)
Ratings	210 (63.5%)	68 (32.4%)	142 (67.6%)
Total	331	121 (36.5%)	210 (63.5%)

*Statistically significant differences assumed at $p < 0.05$

The study employed descriptive statistics to gain an overall understanding of occupational accidents occurred on board ship and chi-square analysis was used to test for significant association between categorical variables (seafarer's age, accident type and etc.) and injury severity. Statistical significance was established at $p < 0.05$.

RESULTS

The study population included 331 seafarer cases of fatal injuries and serious injuries on board merchant cargo ships (Table 2). There were 210 (63.5%) fatal injury cases and 121 (36.5%) serious injury cases. There were no significant differences in rates of injury severity by age, sea experience, and time on board when the accident took place. However, there were significant difference by occupation on board; ratings had significantly higher fatal injury rates compared to officers (56.2% vs. 67.6%, $p = 0.038$). In addition, ratings had two-thirds of the total injuries.

Time on board means the day of the accident from the day the seafarer signed on. Seafarers are signed on the day they arrive on board and the first they are usually used for travel and because of that they have not much time for work on board. In the light of this explanation, it is seen that nine-

tenths of the injuries occurred within the first 6 months after the seafarer joined the ship. As aforementioned, although there is no significant relationship between seafarer age and experience with injury severity, 55% of injuries suffered by seafarers who had 10 years or less sea experience.

The highest frequency of occupational accidents was found on bulk carriers, container ships and general cargo ships with 90, 85 and 72 cases, respectively. Also, there were found significant difference between ship type and injury severity ($p = 0.007$). As seen from Table 3, bulk carriers, container ships and general cargo ships had higher fatal injury rate compared to rest of the ship types in this study. However, there was not found significant difference between ship age and injury severity.

In Table 4, occupational accidents classified based on the activity of seafarers at the time of the accident and accident types were shown. Both accident type and working situation at time of accident were found statistically significant ($p = 0.000$, $p = 0.003$, respectively). Especially, injuries took place as a result of falling from height or falling overboard had remarkable fatality rate (75.2%) and alone accounted for 42.5% of the total injuries. Another accident type that had high fatality rate was exposure to or contact

Table 3. Distribution of injuries according to ship characteristics

Ship's	All cases	Injury severity	
		Serious injury	Fatal injury
Age [year]			
≤ 5	98 (29.6%)	43 (43.9%)	55 (56.1%)
6–10	75 (22.6%)	24 (32.0%)	51 (68.0%)
11–15	56 (16.9%)	17 (30.4%)	39 (69.6%)
16–20	39 (11.7%)	9 (23.1%)	30 (76.9%)
≥ 21	63 (19.0%)	28 (44.4%)	35 (55.6%)
Type*			
Oil/chemical tanker	36 (10.8%)	16 (44.4%)	20 (55.6%)
Bulk carrier	90 (27.1%)	27 (30.0%)	63 (70.0%)
Container ship	85 (25.6%)	26 (30.6%)	59 (69.4%)
General cargo ship	72 (21.7%)	24 (33.3%)	48 (66.7%)
Product tanker	14 (4.2%)	6 (42.9%)	8 (57.1%)
Others	34 (10.2%)	22 (64.7%)	12 (35.3%)

*Statistically significant differences assumed at $p < 0.05$ **Table 4.** Distribution of injuries according to occupational accident characteristics

	All cases	Injury severity	
		Serious injury	Fatal injury
Accident type*			
Falls from height/falls overboard	141 (42.5%)	35 (24.8%)	106 (75.2%)
Struck by rope or chain	46 (13.8%)	18 (39.1%)	28 (60.9%)
Caught or in between objects	46 (13.8%)	24 (52.2%)	22 (47.8%)
Exposure to or contact with extreme temperatures electric current	34 (10.2%)	19 (55.9%)	15 (44.1%)
Exposure to or contact with harmful substances/asphyxiation	42 (12.6%)	16 (38.1%)	26 (61.9%)
Struck by falling objects	10 (3.0%)	7 (70.0%)	3 (30.0%)
Slips, stumbles and falls	12 (3.6%)	2 (16.7%)	10 (83.3%)
Working situation at time of accident*			
Cleaning in tank/hold	28 (8.4%)	9 (32.1%)	19 (67.9%)
Entrance to enclosed spaces	36 (10.8%)	7 (26.9%)	19 (73.1%)
Loading/unloading cargo	67 (20.2%)	25 (37.3%)	42 (62.37%)
Maintenance and repair at engine department	33 (10.0%)	17 (51.5%)	16 (48.5%)
Maintenance on deck	66 (20.0%)	22 (33.3%)	44 (66.7%)
Mooring operations	40 (12.0%)	17 (42.5%)	23 (57.5%)
Rigging and taking in gangways and ladders	18 (5.4%)	2 (11.1%)	16 (88.9%)
Ship drills	34 (10.2%)	20 (58.8%)	14 (41.2%)
Walking from one place to another	19 (5.7%)	2 (10.5%)	17 (89.5%)

*Statistically significant differences assumed at $p < 0.05$

with harmful substances and asphyxiation (61.9%) which occurred mostly during the entrance to enclosed spaces and cleaning in tank/hold on board ship. The most frequent work situations at the time of the accident were maintenance on deck (44 fatalities and 22 serious inju-

ries) and duties fulfilled during the loading and unloading cargo operations (42 fatalities and 25 serious injuries). Furthermore, these two work situations accounted for 40% of total injuries with high fatal injury rates with 66.7% and 62.3%, respectively.

Table 5. Main causes and contributing factors of occupational accidents on board ships

Causes	N (%)
Dangerous work practices and ignorance of rules and instructions	176 (53.2%)
Insufficient risk assessment or hazard identification	49 (19.8%)
Machine/equipment malfunction	37 (11.2%)
Unsafe working environment and adverse weather condition	24 (7.3%)
Lack of education, experience and training	21 (6.3%)
Lack of communication and team work	12 (3.6%)
Deficiencies in instruction and guidance	12 (3.6%)

The most common causal factors that led to occupational accidents were examined in seven categories which were obtained from occupational accident reports (Table 5). Dangerous work practices and ignorance of rules and instructions (53.2%) was found the most common cause of accident (e.g., working in an inappropriate place on board, not using personal protective equipment, dangerous work habits, negligence of snap back zones). Other common factors contributing to the injuries were insufficient risk assessment and hazard identification (19.8%), machine/equipment malfunction (11.2%), inappropriate education, experience and training and unsafe working environment (e.g., rough weather, poor illumination, insufficient ventilation) and lack of communication and team work.

DISCUSSION

Several findings were notable in this study. Ratings (63.5%) were the most affected group suffering from occupational injuries among the crew. This finding is consistent with other international studies that have identified the ratings as having the highest risk of on-duty accidents [4, 13, 15, 18–20]. Similarly, recent studies stated that accidents are generally more frequent among non-officers compared with officers [21, 22]. The reasons of the high risk of occupational injury among ratings are compelling working environment and dangerous works fulfilled on board ship [23].

While the aging seafarer workforce remains an increasing concern [24], our study did not find a significant relationship between seafarer age and injury severity. This is consistent with the study of Lefkowitz et al. [25] who tried to explore risk factors for merchant seafarer repatriation due to injury and illness. On the other hand, Hansen et al. [26] studied on Danish merchant vessels and found the age of seafarer as a contributing risk factor for injury-related disability. Similarly, study of Lefkowitz et al. [27] revealed that higher age is significant risk for work restriction.

Falls on board or falls overboard merchant ships caused almost 42% of the occupational accidents which is the same as reported by Roberts and Marlow [19] for seafarers employed in British merchant shipping. Seafarers largely experienced falls into or inside holds during cargo operations, off ladders or down stairways, falls from heights while working at the ship's side for painting or cleaning, and falls overboard when rigging or de-rigging gangways and pilot ladders. Fatalities and serious injuries through falls overboard or fall on board can substantially be prevented by the more widespread use of self-inflating life vests or safety harnesses when engaged in potentially hazardous operations at great heights or along the sides of ships.

Asphyxiation and exposure to harmful substances in enclosed spaces (12.9%) during entry in holds and tanks for cleaning cargo residue, maintenance and routine inspection have also been reported as one of the most common type of occupational accident among seafarers, which is consistent with other studies [4, 12, 13, 18–20]. Hansen [28] pointed that oxygen contents in enclosed spaces were not properly checked and safety lines were not rigged which caused to delay the rescue. Prevention of enclosed space accidents can be achieved through adherence to recommended procedures and checklists when entering enclosed spaces, which have been extended progressively over time in shipping [29].

Being struck by mooring or towing ropes and chain of anchor during the mooring and anchoring operations is one type of occupational accident causing fatal and serious injuries among seafarers. Hazards often appear when the ropes become tense due to sudden unpredictable ship movements, use of worn ropes/wires and negligence of snap back zones. Also, weak communication among the crew and between ship and shore personnel was one of the main causes of mooring accidents. These types of accident can be avoided by maintenance and replacement of worn ropes regularly and abstaining from standing in proximity to ropes under stress. Besides, before planning the mooring and anchoring operations, considering the weather condition factors such as wind and current is crucial for prevention of unforeseeable ship movements.

The most critical cause of occupational accidents was found the dangerous work practices and ignorance of rules and instructions (e.g., not using personal protective equipment, dangerous work habits, and negligence of snap back zones) in this study. In the studies of Oldenburg et al. [14] and Uğurlu et al. [30], it was also found that lack of using or improper use of personal protective equipment was the primary causal factor leading to fatalities or serious injuries. Also, insufficient risk assessment or hazard identification deficiencies in instruction or guidance, machine/equipment malfunction and inappropriate education, experience and training were the other main causes of occupational accidents on board merchant cargo ships.

CONCLUSIONS

Occupational accidents are still crucial concern in maritime industry which imposes a major burden on both seafarers and shipping companies. However, our study showed that injuries frequently resulted from human error such as dangerous work practices and ignorance of rules and instructions. Reduction in occupational injuries could be achieved by improving the working environment and the quality of life on board, mitigating the mental and physical burden of work and developing policies to encourage the seafarers to obey safety rules and instructions.

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