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Insights from the analysis of occupational accidents onboard ships

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ABSTRACT

The maritime working environment includes physical, ergonomic, environmental, psychological, and cultural contributors which may lead to the occurrence of occupational accidents and injuries. Therefore, the identification of underlying causes of fatalities, as well as non-fatal occupational injuries onboard ships, is essential to define priorities and design effective preventive strategies on occupational health and safety. This paper presents the results from a descriptive analysis of onboard ships occupational accidents conducted on a historical database and describe the existing gaps in occupational accidents data collection and analysis. Moreover, recommendations to overcome these gaps are provided.

Keywords: *Occupational accidents onboard ships, Injuries, Fatalities, Causal Factors*

1. INTRODUCTION

Maritime transportation is one of the largest and most globalised industries in terms of operations. Maritime operations rely on seafarers who are responsible for the ship navigation and transportation of cargo. Seafaring has been recognised as a high-risk occupation as seafarers are exposed to a variety of occupational health hazards onboard ships. Moreover, seafarers face demanding working conditions, isolation, long hours of work, high levels of work pressure and fatigue. Different types of activities are carried out onboard ships, and these activities may involve a variety of hazards to which seafarers are exposed. The types of accidents resulting from the crew exposure to hazards include falling from a height, hit by moving objects, machinery explosion, enclosed space, hot work, electrical shock accidents, man overboard, etc. According to the European Maritime Safety Agency, from 2014 to 2019, the majority of occupational accidents that resulted in fatalities were caused by falls (EMSA, 2020). Additional, occupational accidents leading to crew injuries included loss of control of machinery, leaks, fire and explosion. There are different sources of occupational accidents data, and these sources include databases created by different organisations and detailed accident reports prepared by national administrations.

The Global Integrated Shipping Information System (GISIS) is developed and maintained by the International Maritime Organisation (IMO). This database provides a data hub for the shipping industry and maritime professionals, and access to this database is provided to the public after registration (IMO, 2021).

The European Marine Casualty Information Platform (EMCIP) is a database and a data distribution system operated by the European Maritime Safety Agency (EMSA), the European Commission and the EU/EEA Member States. EMCIP aims at improving the information about marine casualties and incidents by providing the results of the analysis of reported casualties and accident investigations (EMSA, 2021).

CHIRP Aviation and Maritime Confidential Incident Reporting provides an independent confidential (not anonymous) reporting system for individuals employed in or associated with the aviation and maritime industries (CHIRP, 2021).

Mariners' Alerting and Reporting Scheme (MARS). MARS is a confidential reporting system that is run by The Nautical Institute. the aim of this system is to allow anonymous reporting of both accidents and near misses. MARS' reports contain a description of the accidents and near-misses reports. In some cases, these reports include the lessons learnt.

Another source of accident and incident data is the accident investigation reports which are publicly available for serious injuries, fatalities, or severe shipping accidents. Commonly, these reports are prepared and made available by national administrations and provide a detailed description of the causal factors and root causes of accidents.

The data sources available for maritime occupational accidents vary in terms of the level of details provided, the approach used for collecting accident data, the format in which data is displayed, and the accessibility.

Detailed statistics on occupational accidents onboard ships are often incomplete because under-reporting is common as some administrations provide only the minimum required information with regards to the accident. Additionally, scarce data is also found when a complete accident investigation was not carried out.

The minimisation of inconsistencies among various databases and the improvement of the quality of data collected can be achieved by developing a more homogenous approach and standardised accident reporting terminology, which can be implemented across various stakeholders including national authorities, shipping companies and P&I clubs.

2. SEAFARERS WELLBEING

Seafarers' wellbeing combines physical, mental, and social wellbeing. Although improvements have been made in seafaring, it is recognised as a demanding, stressful and high-risk occupation with potential effects on the physical and mental health of the seafarers. There is a link between seafarer's health and their operational performance (Givati, 2018). If the health of seafarers is compromised, it may affect their ability to perform a task or their response to an emergency situation in the workplace.

Previous research studies aimed at identifying the factors contributing to the psychological wellbeing of seafarers have identified that isolation, long and irregular working hours, demanding task, time pressure, and long periods onboard are the greatest contributors (Oldenburg, Hogan, & Jensen, 2013).

The effect of working hours on safety, productivity and wellbeing has been an area of concern in various transportation sectors. In the maritime domain, research studies have shown that fatigue can affect seafarers' health and also diminished work performance. For example, irregular working periods have negative effects on the health of seafarer due to the biological 24-hr rhythm and sleep loss (Lützhöft, Thorslund, Kircher, & Gillberg, 2007).

Another important factor to be considered is fatigue, which is often mentioned in accident reports as a potential contributor to accident occurrences. Akamangwa (2016) studied the influence of stress, wellbeing and injury in the workplace; in this study, it was found that demands from an increased workload and longer working hours are relevant indicators of job stress.

Additionally, research studies suggest that seafarers are more likely than the general population to engage with unhealthy behaviours. For example, a study of 1,806 Australian seafarers in 1997 showed that, compared to surveys of the Australian general public, seafarers smoked and drank more, exercised less and consumed more sugar and fat (Parker, Hubinger, Green, Sargent, & Boyd, 1997).

Seafarers' mental health and wellbeing can be impacted by poor working conditions and long working hours. In extreme cases, poor mental health and depression may lead to suicide among seafarers. In a comparative investigation carried out by S. E. Roberts, Jaremin, and Lloyd (2013) the suicide rates for different occupations in Britain were studied. In this study, it was found that for the time periods of 1979-80, 1982-1983, and 2001-2005 merchant seafarers was one of the occupations with the highest suicide rates. Previous studies analysed the historical seafarers' suicide frequencies (Stephen E. Roberts, Jaremin, Chalasani, & Rodgers, 2010; S. E. Roberts & Marlow, 2005; S. E. Roberts, Nielsen, Kotlowski, & Jaremin, 2014). However, there is not enough information about the risks of suicide and its links to factors such as geographical location, type of ships, crew nationality, rank and age. (Stephen E. Roberts et al., 2010). In a study conducted by S. E. Roberts and Marlow (2005), the authors identified that from 1976 to 2005, work-related issues were cited as a major contributing factors in about 30% of suicides.

Thus, the collection and analysis of occupational accidents along with factors associated with the wellbeing and mental health of seafarers, are key for identifying safety performance contributors and underlying reasons for accidents. The implementation of such data-driven approach will support the development of strategies to minimise the occurrence of occupational accidents and reduce the rates of injuries and fatalities among seafarers.

This paper focuses on the analysis of direct causal factors contributing to occupational accidents and the identification of existing gaps associated with the quality of the available data.

3. ANALYSIS METHODOLOGY

The descriptive analysis was conducted on a historical accident database provided by the Marine Accident Investigation Branch (MAIB). The descriptive analysis presents:

- an overview of the injuries and fatalities for a different type of vessels
- the identification of the most common type of injuries,
- a summary of the identified main causal factors of occupational accidents.

The analysed database has more than 10000 entries related to crew occupational accidents. The analysis conducted includes only the occupational injuries and fatalities which occurred on board UK flagged merchant vessesl over 500GT worldwide or onboard foreign flag merchant vessels over 500 GT while they were in UK waters. Only the occupational accidents onboard merchant ships are considered in this analysis.

The analysis was conducted separately for cases that resulted in injuries and fatalities. The EMSA taxonomy, which is followed by all EU and associated countries, including the UK, is for the analysis (EMSA, 2016).

EMCIP taxonomy has been used by European Member and EEA states for accident reporting. With regards to occupational accidents, it provides taxonomies to capture different factors at different levels of detail.

The EMCIP taxonomy covers four main categories: generic information, factual information, additional information and casualty analysis (EMSA, 2016). Some of the values of each category of data are classified using two levels of detail.

The MAIB occupational accident database is also based on the EMCIP taxonomy. Figure 1 shows an example of values with two levels of data. The factors considered in the analysis include the type of ship, mode of injury, deviation part of the body injured and type of injury Level 1 category (Figure 2).

Level 1	Level 2
Body movement under or with physical stress (generally leading to an internal injury)	Lifting, carrying, standing up (Lifting, carrying, standing up)
	Pushing, pulling (Pushing, pulling)
	Putting down, bending down (Putting down, bending down)
	Twisting, turning (Twisting, turning)
	Treading badly, twisting leg or ankle, slipping without falling (Treading badly, twisting leg or ankle, slipping without falling)
	Other (Other)
Loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal	Loss of control (total or partial) - of machine (including unwanted start-up) or of the material being worked by the machine
	Loss of control (total or partial) - of means of transport or handling equipment, (motorised or not)
	Loss of control (total or partial) - of hand-held tool (motorised or not) or of the material being worked by the tool
	Loss of control (total or partial) - of object (being carried, moved, handled, etc.)
	Loss of control (total or partial) - of animal
	Other (Other)
Slipping - Stumbling and falling - Fall of persons	Fall of person - to a lower level
	Slipping - Stumbling and falling - Fall of person - on the same level
	Fall overboard of person
	Other

Figure 1. Examples of Level 1 and Level 2 values in EMCIP taxonomy

EMCIP taxonomy extracts for occupational accidents	
Level 1	**Level 2**
Type of Ship –Level 1	Type of Ship-Level 2
Deviation-Level 1	Deviation Level2
Mode of Injury –Level 1	Mode of Injury –Level 2
Part of Body Injured-Level 1	Part of Body Injured Level 2
Type of Injury –Level 1	Type of Injury –Level 2

Figure 2. EMCIP taxonomy values used in this analysis

4. RESULTS AND DISCUSSION

4.1 Frequency of injuries and fatalities

The records of occupational accidents in the database start from the early 90's, Figure 3 shows that the frequency of occupational injuries has been decreasing over the years. A similar trend (slight reduction in occupational injuries trend) is presented in the EMSA annual review report (EMSA, 2020), which presents the data collected from EU countries since 2014. Figure 4 displays the frequency of fatal occupational accident data and it can be observed that fatal occupational accidents show a decreasing trend over the years.

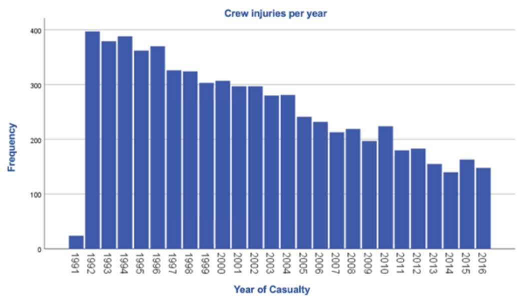

Figure 3: Crew injury frequencies onboard merchant vessels recorded in UK MAIB database

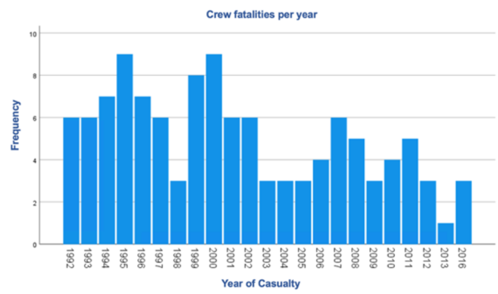

Figure 4: Crew fatality frequencies onboard merchant vessels recorded in UK MAIB database

4.2 Type of vessel

Certain injuries might be more common for certain vessel types due to the nature of these vessels and the type of cargo that they transport.

From the database analysis, it was found that passenger and ro-ro cargo vessels (40.1%) are at the top of the list of ship types with the highest frequency of onboard occupational injuries (Figure 5). They are followed by the solid cargo vessels (15.8%). Passenger only vessels (14.8%) are ranked as the third-highest ship type in the list, followed by liquid cargo vessels (8.2%) and offshore supply ships (5.7%).

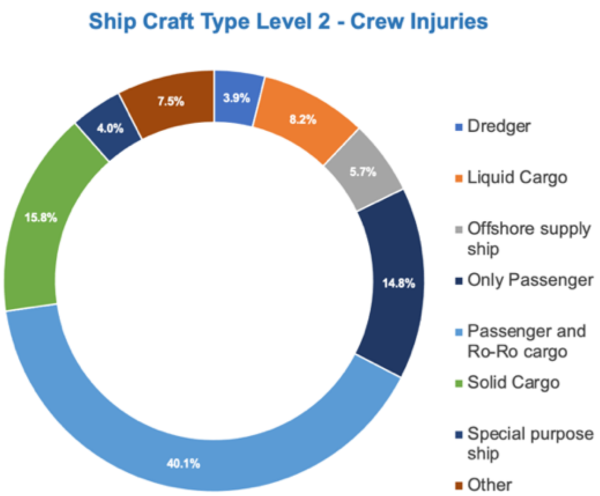

Figure 5. Distribution of crew injuries onboard different merchant vessels recorded in the UK MAIB database

For crew fatalities, the analysis indicated that 60.3% of occupational fatalities occur onboard solid cargo vessels (Figure 6). Liquid cargo vessels (12.1%), followed by passenger and Ro-Ro vessels (6.9%), and then passenger-only vessels (6%). A similar trend is presented in the EMSA annual review report (EMSA, 2020) where the majority of fatalities occurred in cargo vessels which include solid cargo (e.g. bulk carriers, container ships, general cargo, refrigerated cargo, etc,) and liquid cargo (e.g. chemical tankers, liquified gas tankers and oil tankers, etc).

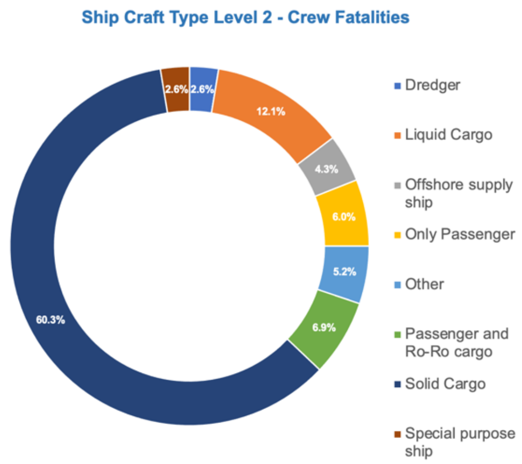

Figure 6. Distribution of crew fatalities onboard different merchant vessels recorded in the UK MAIB database

4.3 Causal Factors

'Slipping, stumbling and falling-fall of persons', with 40.7%, is the most common causal factor for occupational injuries onboard merchant vessels (Figure 7). With 24.4% 'Loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal' is the second most common causal factor followed by 'body movement under or with physical stress leading to an internal injury, with 18.5%.

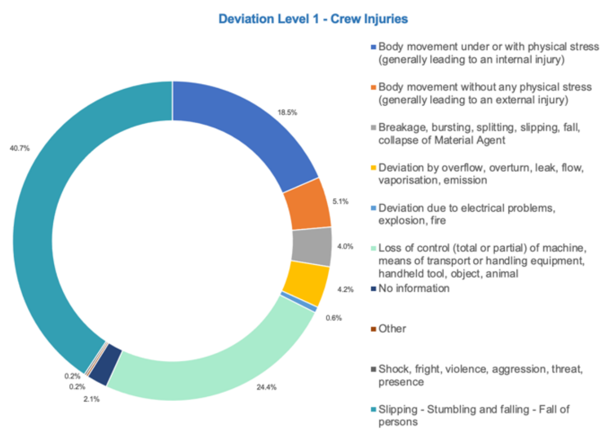

Figure 7: Level 1 causal factors for crew injuries onboard merchant vessels recorded in the UK MAIB database

Similarly, in EMSA's annual report, it was identified that most of the injuries (36.2%) occurred due to slipping/falls of persons. The second deviation with the highest percentage reported is body movement without any physical stress (21%), followed by 'loss of control of machine; means of transport or handling equipment (18%).

For crew fatalities, 'slipping, stumbling and falling-fall of persons', with 46.5%, is the most common causal factor followed by 'loss of control (total or partial) of machine, means of transport or handling equipment, handheld tool, object, animal' (25%) and 'deviation by overflow, overturn, leak, flow, vaporisation, emission' (11.2%).

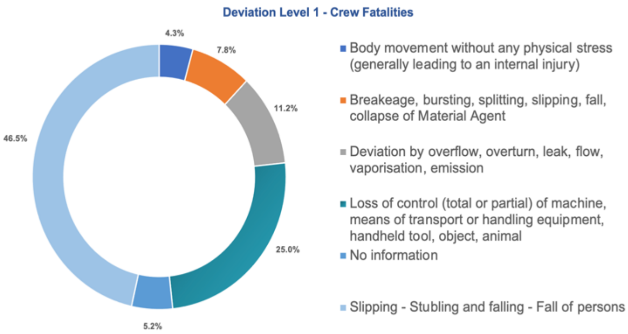

Figure 8: Level 1 causal factors for crew fatalities onboard merchant vessels recorded in the UK MAIB database

Similarities were identified with the EMSA annual review report for two of the main contributors, where 'slipping/falling of persons' is the main deviation followed by 'deviation by overflow overturn; leak; flow; vaporisation; emission' and 'Body movement without any physical stress'. 'Fall from Height' appears to be the main reason for the fatalities.

4.4 Injury type

Investigation of the injury types provides insight into the nature of the injuries sustained by the crew. Figure 9 indicates the most common Level 1 injury types as 'dislocations, sprains and strains' with (27.4%), followed by 'bone fractures' (25.2%) and 'wounds and superficial injures' (24.9%).

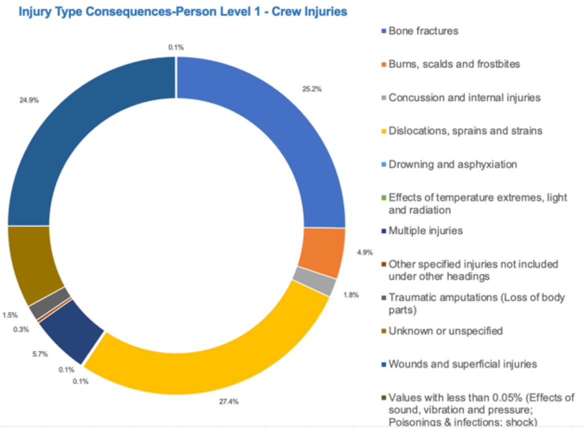

Figure 9: Level 1 injury types which the crew sustained onboard merchant vessels recorded in the UK MAIB database

For crew fatalities, Figure 10 indicates that Level 1 injury types are unknown or unspecified for slightly over 90% of the data. From the available data, 'concussion and internal injuries' (3.4 %) and 'multiple injuries' (3.4%) represent the most common injury types.

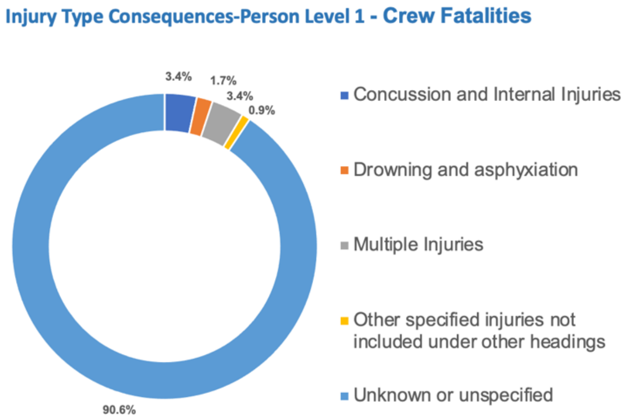

Figure 10. Level 1 injury types which caused crew fatalities onboard merchant vessels recorded in the UK MAIB database

4.5 Mode of Injury

Figure 11 provides the frequencies of the different modes of injuries. In this analysis, approximately 85% of the modes of injury information is not available. Insufficient data creates a major barrier that impacts the accuracy of the analysis of underlying reasons for injuries and the effective identification of preventive measures. From the available data, 'trapped, crush, etc' (7.3%) and 'contact with electrical voltage, temperature, hazardous substances etc' (4.6%) are the identified most common mode of injuries.

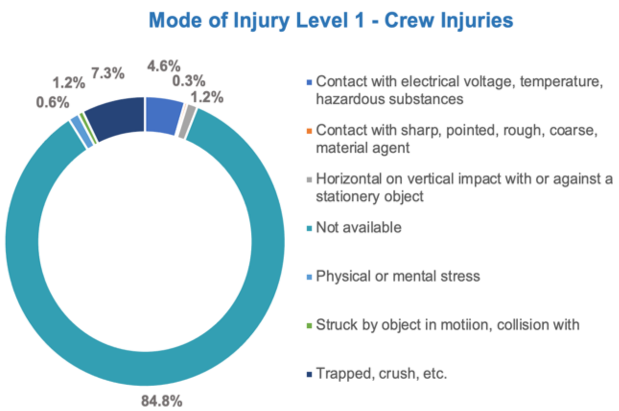

Figure 11: Level 1 mode of injury onboard merchant vessels recorded in the UK MAIB database.

For crew fatalities (Figure 12), approximately 91% of the modes of injury information are not available. From the available data, 'Horizontal or vertical impact with or against a stationary object' (2.6%) and 'Struck by an object in motion, collision with (2.6%) represent the most common contributors.

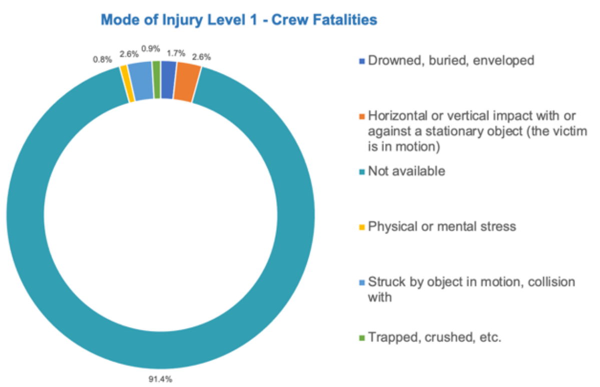

Figure 12: Level 1 mode of injury which caused fatalities onboard merchant vessels recorded in the UK MAIB database

4.5 Part of the body Injured

The part of the body injured was not reported for 75% of the injuries. From the known data, 'Back, including spine and vertebra in the back' (10.7%) is the most common part of the body injured, followed by 'Upper extremities' (4.7%) and 'Head' with 3.8% (Figure 13).

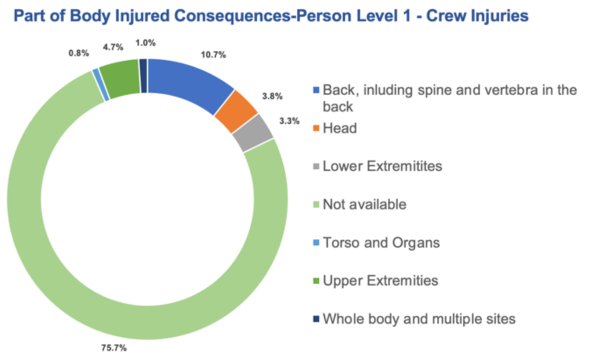

Figure 13: Level 1 distribution of parts of the body, injuries recorded in the UK MAIB database

For crew fatalities, 94% of the part of the body injuries that result in fatalities were due to the whole body and multiple sites, followed by torso and organs (3.4%) and head with 1.7% (Figure 14). The terminology and the approach followed for the collection of the data are essential to maximise the benefits of available data. For instance, 95% of the modes of injury information are not available, which may suggest that reporting forms are incomplete. Similarly, for the part of the body injured for crew members who sustained injures, approximately 75% of the data is not available.

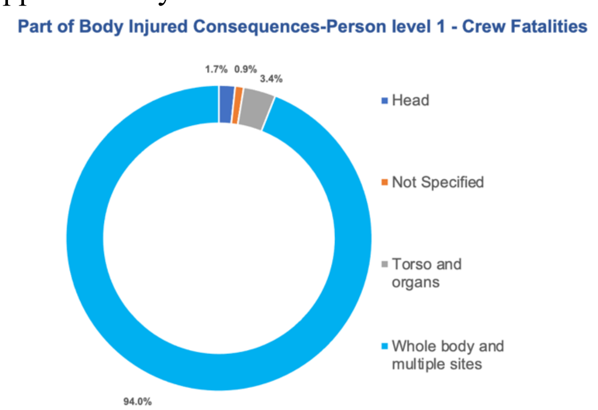

Figure 14: Level 1 distribution of parts of the body injured, resulting in fatalities as recorded in the UK MAIB database

Various publications highlight gaps and inconsistencies in the available occupational accidents data. These gaps, along with the inconsistency in data collection, affect the quality of data, creating major challenges in their interpretation and, therefore, the development of occupational health and safety policies and procedures aiming at reducing the rate of occupational accidents. It is essential to have a standard taxonomy for purposes of compatibility of the data collected from various data sources since identifying reliable correlations between causal and underlying factors is very challenging and complex (Figure 15). Solutions such as advanced predictive techniques (e.g. machine learning) could be used to learn from the data and improve their accuracy over time. However, existing gaps in available data and the lack of standardisation in the collection approach limit the scope of the analysis. Additionally, missing information and discrepancies in collected data creates uncertainty in the results and may impede the accurate identification of correlations among underlying causes and occupational accidents occurrences.

Figure 15: Relationship among underlying contributors to occupational accidents.

Another problem is under-reporting. Although the EMCIP taxonomy is available, in most cases, reporting forms for occupational injuries are not reflecting the full application of this taxonomy. This might be explained by the fact that some fields require the input of free text. In addition, it was identified that there is a major gap in the collection of contributors associated with human and organisation related actions. For instance, the EMCIP taxonomy provides a comprehensive terminology for capturing human factors (Figure 16). However, in the database analysis, this type of data was not available for occupational accidents.

Examples of human-related factors in EMCIP's taxonomy		
Error Modes	Action at a wrong time (Action at a wrong time)	Too early
		Too late
		Omission
Temporary Conditions	Distraction	Goal forgotten
		Loss of orientation
		Task not completed
		Task suspended
Inadequate design factors	Design of Ship	Anthropometric factors
		Reliability of Equipment
		Level of Automation
		Level of Redundancy

Figure 16: Example of human-related factors in EMCIP taxonomy.

5. CONCLUSIONS

Although a variety of databases, accident reports and reporting systems exist, the availability of detailed occupational accidents information such as description of causes associated to human factors and the severity of injuries is limited.

Detailed statistics on occupational accidents onboard ships are often incomplete because under-reporting is common as some administrations provide only the minimum required information with regards to the accident. Additionally, scarce data is also found when a complete accident investigation was not carried out due to limited resources.

A number of researchers have pointed out the gaps among occupational accidents data which are related to data availability and accessibility, quality, level of detail, and compatibility with different occupational accident data sources. This represents a major barrier to conduct a more comprehensive analysis to support the identification of contributory factors and root causes for occupational accidents. Considering the need for having occupational accidents data of good quality, the creation and implementation of a standardised framework for data collection are of paramount importance. Moreover, in a world where data is more important than ever, the development of novel approaches for data prediction and analysis should be one of the top research priorities. Thus, exploring advanced predictive algorithms such as machine learning to support the generation of data, identification of trends and predictions for occupational accident occurrences represents the way forward to uncover the underlying reasons and make better predictions of accidents and incidents occurrences

Equally important is to consider the mental health of seafarers, which is a growing issue that may be correlated to performance and the occurrence of occupational injuries and fatalities. For instance, the mental state of the seafarers may have an impact on seafarers' navigational performance onboard ships. Unfortunately, current databases very rarely mention the fatalities due to suicide etc. as 'man overboard' is the usual term encountered in database.

Therefore, more novel approaches and methodologies need to be developed in order to collect wellbeing and mental health factors and identify their correlation with poor safety performance. In this area, the advances in technology play an important role as the collection of this type of data could be supported by the use of wearable technology.

Finally, the unification of efforts in this area is key as there is limited cooperation between various research groups. The lack of cooperation will create limited opportunities for sharing the findings and lessons learnt from this type of analysis. In addition, the implementation of a more standardised methodology will help to improve the quality and availability of data and ultimately support the development of solutions for preventing occupational accidents and reduce the rates of injuries and fatalities in merchant seafarers.

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