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Epidemiology of occupational injuries and diseases among seafarers: Implications for prevention

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Abstract

Objectives: Workers at sea have high mortality, injuries, and illnesses, and work in a hazardous environment compared to ashore workers. The present study was designed to measure the incidence of diseases and occupational injuries among seafarers and to quantify the contribution of rank and duties on board on seafarers' illnesses and injuries rates.

Methods: A retrospective study was employed, and the study used the International Radio Medical Center (C.I.R.M) database of seafarer's injuries and diseases from 2016 to 2019. The chi-square or Fisher's tests were used to determine differences in rank and worksite groups. The Z-test for proportions and independent samples t-test were used to compare proportions and means, respectively. P-value <0.05 was considered statistically significant. The STATA software version 15 was used for data analysis.

Results: The total disease rate was 25 per 1,000 seafarer-years and the overall injury rate was 6.31 per 1,000 seafarer-years over the four years study period. Non-officers had significantly higher risk for gastrointestinal [IRR: 2.12 (95% CI) = 1.13 – 4.26; p = 0.011], dermatological [IRR: 3.66 (95% CI) = 1.27 – 14.42; p = 0.006] and musculoskeletal [IRR: 2.25 (95% CI) = 1.11–5.05; p = 0.015] disorders compared to officers. Deck workers had 3.25 times higher risk for wrist and hand injuries compared to engine workers.

Conclusions: In general, non-officers and deck workers had a higher risk for diseases and injuries. Future studies should consider risk factors for injury and illness among seafarers in order to propose further preventive measures.

Keywords: Epidemiology, Injury, Disease, Seafarer, Rank, Occupation

Strengths and limitations of this study

- This study measured the incidence rates of injury and disease for rank and occupation groups
- The study measured the contribution of differences in rank and duty to the rates of injury and illness of seafarers on board merchant ships.
- The estimated at-risk seafarer population was used in the analysis due to the lack of information on actual at-risk seafarer population.

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively[1]. It is estimated that nearly 65,000 deep-sea merchant ships operate around the world, carrying more than 1.6 million sailing seafarers[1,2].

In general, work onboard ships are broadly grouped by working areas, including deck, engine, and galley[3]. Shipping is one of the most widespread transportation systems, and more than 88% of the world's trade utilizes it[4,5]. Workers at sea have high mortality, injuries, and illnesses rate compared to ashore workers[5]. Sailing seafarers have one in eleven chances of being injured on duty on board [6], and sometimes physical injuries can be acute and a primary cause of disability. Different studies have reported higher mortality and morbidity rates onboard merchant ships when compared to the land occupation. For instance, a study conducted on the British merchant fleet reported that between 2003 to 2012, the fatal incident rate in shipping was 21 times higher than that in the general British workforce, 4.7 times higher than that in the construction industry and 13 times higher than in manufacturing[7]. Mortality in Danish seafarers onboard ships was found to be 11.5 times higher compared to Danish male ashore workers between 1986 to 1993[8]. Moreover, seafarers working on board of British merchant ships had 23.9 times higher risk of death compared to all workers in Great Britain[9]. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km[10].

The identification of the potential area of incidents and the assessment of the probability of the occurrence of occupational medical events (illnesses and injuries), may assure the availability of treatment and the development of prevention strategies to reduce the rate of diseases and/or injuries among seafarers and to improve health outcomes[11–13]. Unfortunately, due to the scarcity of evidence-based information on the incidence of occupational diseases and injuries onboard ships, preventive measures in the maritime environment received less attention compared to other working activities [14]. On the other hand, determinants of onboard merchant ship illnesses, injuries, disability, and fatalities, remain not adequately studied due to the not easy access of seafarer's medical data[3,13,15]. Previous studies have reported that non-officers have a higher risk for diseases and injuries compared to officers[3,15–18], but most of these studies considered only occupational groups.

The exposure to the work-related risk of officers and non-officers working in different ship areas such as deck, engine, and galley is not similar, because they attend different duties in different working hours[19]. For instance, workers in the engine room are exposed to work-

related risks such as noise, vibration, and heat or pollutants during their working hours[19,20]. In contrast, people working in the deck, as well as in the galley, are potentially exposed to different work-related risks[19]. Because of the different areas of activity and associated burden, the likelihood of illnesses and the occurrence of injuries can differ, and evidence-based information can be used for preventive measures.

The aim of present study was to analyze the incidence of occupational diseases and injuries among seafarers by worksite and rank groups. This work provides factual information on the risk of illnesses and injuries between the worksite group as well as the rank. The results obtained can be used to prioritize occupational health risks and guide the development of preventative measures onboard merchant ships.

2. METHODS

2.1. Study design, data source, and collection procedure

We employed a retrospective study design and received data from the Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M) database. C.I.R.M is the Italian Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best known TMAS worldwide. C.I.R.M operates since 1935 and has assisted more than 100,000 seafarers onboard ships [21]. For this particular study, we have used CMA CGM group vessels' occupational illnesses, and injuries claim records. CMA CGM shipping company has made an agreement with C.I.R.M in January 2016 to identify new approaches to provide high-quality telemedical assistance for seafarers. In view of this agreement, data provided for medical assistance on board ships of the company are more detailed and, therefore, can be used for a basic epidemiological analysis.

Work-related diseases are illnesses predominantly due to physical, chemical, and biological factors associated with merchant seafaring occupations, and they are recorded in the CIRM database according to the World Health Organization (WHO) International Classification of Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden, unexpected, and unwanted forceful event due to an external cause onboard merchant seafaring occupation. In the C.I.R.M database, injuries also are recorded according to the WHO ICD 10th revised version (chapter XIX, S00-S99, and T00-T98).

The classification of both illnesses and occupational injuries was made according to the prompt diagnosis and recorded medical datasets in the C.I.R.M database. The attributes included in

the database were age, gender, rank, working site, type of vessel, means of contacts, days, months, and years of diagnosis. Disease and injury diagnosis affected body parts, and ICD 10 for both diseases and injuries were included in the dataset. For the analysis of the incidence of illnesses and injuries, the rank and worksite groups were the parameters considered.

An estimated total number of at-risk seafarer population was calculated by multiplying the number of vessels during the study period by the average number of crew members per vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an average size of 20-25 crew members per ship[3]. The CMA CGM shipping company handles only container ships, with an average of 25 crew members per ship. Regarding rank distribution per ship, nine officers and sixteen non-officers (ratings) serve onboard. In respect of worksite, ten deck workers, thirteen engine workers and two galleys (catering) workers are in service per vessel. The average number of the crew size, their rank as well as worksite distribution per large vessel based on the knowledge of industry norm were calculated.

The number of CMA CGM container ships contracted over four years from January 2016 to December 31, 2019, was 539. An estimated number of the total at-risk seafarer population for worksite and rank was determined by multiplying the total number of vessels over four years by occupation and rank distribution per ship. The total number of seafarers at risk was adjusted proportionally to the number of seafarers in the dataset for whom information on occupation and rank was available. Then, worksite and rank specific incidence rates were calculated by dividing the number of cases by the total at-risk seafarer population for each occupation and rank over four years. Moreover, the incidence rate ratio (IRR) and 95% confidence interval were performed to quantify the rate difference between rank groups as well as worksite groups. The outcome of rates was expressed as per 1,000 seafarer-years.

2.2. Statistical analysis

Descriptive analysis of seafarer's demographic variables, including age, rank, and worksite, was done to evaluate the distribution of occupational injuries and diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley). The worksite was also categorized into three groups, including the deck, engine, and galley. The Chi-square or Fisher's exact test was used to determine distributional differences in rank and worksite groups. The Z- test and independent-sample t-tests to compare mean and proportions, respectively, were used. A two-tailed $P < 0.05$ was considered statistically significant. The STATA software version 15 was used for data analysis.

2.3. Patient and public involvement

Patients and public were not involved in the study

3. RESULTS

3.1. Socio-demographic characteristics

Overall, 423 patients have assisted onboard CMA CGM group container ships over the four years study period. Of these, 338 (80%) and 85 (20%) were diseases and injuries, respectively. The mean age (SD) of seafarers with illnesses and injuries was 40.37 ± 12.52 years and 38.39 ± 12.88 years, respectively. Diseases occurred almost seven times more frequently in the deck workers compared to galley workers by worksite (Table 1).

Table 1. Characteristics of seafarers with diseases and injuries from 2016 to 2019 (n = 423)

Variables	Medical Events		Total (n = 423) n (%)
	Disease (n = 338) n (%)	Injury (n = 85) n (%)	
Age group			
≤ 30	89 (26.3)	31 (36.5)	120 (28.4)
31 – 40	96 (28.4)	22 (25.9)	118 (27.9)
41 – 50	78 (23.1)	15 (17.6)	93 (22)
≥51	75 (22.2)	17 (20)	92 (21.7)
Mean (SD)	40.37 ± 12.52	38.39 ± 12.88	39.97 ± 12.60
Rank			
Officer	84 (24.9)	19 (22.4)	103 (24.4)
Non-officer	217 (64.2)	59 (69.4)	276 (65.2)
Unknown	37 (10.9)	7 (8.2)	44 (10.4)
Worksite			
Deck	171 (50.6)	43 (50.6)	214 (50.6)
Engine	105 (31.1)	28 (33)	133 (31.4)

Galley	25 (7.4)	7 (8.2)	32 (7.6)
Unknown	37 (10.9)	7 (8.2)	44 (10.4)

The most frequent causes of illnesses onboard ships were gastrointestinal disorders (n = 71, 21.30%) followed by musculoskeletal (n = 52, 15.38%) and cardiovascular diseases (n = 51, 15%) (Figure 1). In general, out of the 85 injuries, 29.40% were wrist and hand injuries, 21.20% were knee/lower leg injuries, 12.90% were head/eye injuries, 11.80% were lower back/lumbar spine injuries, 8.2% were thorax/neck injuries (Figure 2).

3.2. Rank-specific incidence rates of diseases and occupational injuries

Non-officers had the highest both total disease (28.26 per 1,000 seafarer-years) and injury (7.5 per 1,000 seafarer-years) rates. IRR was calculated to quantify the difference in the rate of diseases and injuries between the seafarers' rank group. As a result, non-officers had significantly higher rates of gastrointestinal, musculoskeletal, and dermatological disorders compared to officers. Concerning injuries, non-officers had 1.75 times higher risk for total injuries compared to officers (Table 2).

Table 2. Incidence Rate of diseases and occupational injuries by the seafarer rank from 2016 to 2019 (n = 379)

Medical events	Officer		Non-officer		Difference		P-value
	Rate	95% CI	Rate	95% CI	IRR	95% CI	
Diseases							
Gastrointestinal	3.1	1.64 - 5.24	6.51	4.82 - 8.59	2.12	1.13-4.26	0.011
Musculoskeletal	2.14	1.03 - 3.94	4.82	3.45 - 6.56	2.25	1.11-5.05	0.015
Cardiovascular	2.69	1.29 - 4.95	4.39	2.95 - 6.31	1.63	0.77 – 3.75	0.179
Non-specific	2.86	1.47 - 4.99	2.68	1.64 - 4.14	0.94	0.44-2.10	0.849
Respiratory	2.59	1.29 - 4.63	2.25	1.31 - 3.60	0.87	0.38 – 2.05	0.711
Dermatological	0.88	0.24 - 2.25	3.22	2.10 - 4.71	3.66	1.27-14.42	0.006
Genitourinary	2.06	0.99 - 3.78	1.27	0.64 - 2.28	0.62	0.24-1.63	0.280
Eye/Adnexa	1.31	0.48 - 2.86	1.23	0.59 - 2.27	0.94	0.31-3.14	0.887
Infectious and parasitic	1.26	0.4 - 2.94	0.57	0.15 - 1.45	0.45	0.09-2.09	0.250
Ear/Mastoid	0.41	0.05 - 1.49	0.46	0.13 - 1.19	1.13	0.16-12.44	0.927
Neurological	-	-	0.46	0.13 - 1.19	-	-	-

Mental/behavioral	0.21	0.005 - 1.14	0.35	0.07 - 1.02	1.69	0.14-88.59	0.713
Total	19.44	15.54 - 24.02	28.26	24.66 - 32.21	1.45	1.12-1.89	0.003
Injury							
Wrist and Hand	1.72	0.74 - 3.38	1.93	1.11 - 3.14	1.13	0.45 – 3.03	0.801
Knee/lower leg	0.44	0.05 - 1.57	1.84	1.03 – 3.03	4.21	1.01 – 38.01	0.032
Head/Eye	0.76	0.16 - 2.21	0.85	0.31 - 1.85	1.13	0.24-6.95	0.898
Lower back/lumbar spine	0.77	0.16 - 2.25	0.73	0.24 - 1.69	0.94	0.18-6.07	0.911
Thorax/neck	0.21	0.005 - 1.14	0.69	0.25 - 1.51	3.37	0.41-155	0.261
Skin burn	0.21	0.005 - 1.14	0.58	0.19 - 1.35	2.81	0.31-133	0.369
Upper arm/shoulder	0.27	0.006 - 1.53	0.46	0.09 - 1.35	1.69	0.14-88.6	0.71
Elbow/forearm	-	-	0.46	0.13 - 1.18	0	0	-
Total	4.3	2.57-6.66	7.5	5.68 - 9.61	1.75	1.03 – 3.10	0.029

**IRR = Incidence rate ratio and calculated as the rate of non-officer/rate of officer*

3.3. Worksite-specific incidence rates of diseases and occupational injuries

Table 3 summarizes the rates of illnesses and injuries per seafarer worksite groups. Deck workers had the highest rates of both overall diseases (35.63 per 1,000 seafarer-years) and total injuries (8.69 per 1,000 seafarer-years).

Medical events	Deck		Engine		Galley	
	Rate	95% CI	Rate	95% CI	Rate	95% CI
Diseases						
Gastrointestinal	7.01	4.83 - 9.83	3.76	2.38 - 5.63	6.37	2.34-13.83
Musculoskeletal	5.40	3.59 - 7.79	2.52	1.47 - 4.04	4.82	1.56-11.22
Cardiovascular	6.06	3.93 – 8.94	1.86	0.89 – 3.43	4.85	1.32-12.38
Non-specific	3.86	2.29 – 6.09	2.15	1.14-3.66	1.07	0.03 – 5.96
Respiratory	3.82	2.26 – 6.02	1.46	0.67 – 2.78	1.06	0.03 – 5.89
Dermatological	3.96	2.42 – 6.11	0.91	0.34 – 1.98	3.96	1.08 – 10.09
Genitourinary	2.04	1.02 – 3.65	1.28	0.59 – 2.43	0.93	0.02 – 5.16
Eye/Adnexa	1.38	0.56 – 2.84	1.21	0.52 – 2.39	0.98	0.03 – 5.48
Infectious and parasitic	1.13	0.37 – 2.64	0.69	0.19 – 1.79	-	-

Ear/Mastoid	0.19	0.004 – 1.03	0.57	0.16 – 1.46	10.93	0.02 – 5.16
Neurological	0.37	0.05 – 1.34	0.14	0.003 – 0.79	0.93	0.02 – 5.16
Mental/behavioral	0.56	0.12 – 1.62	0.14	0.003 – 0.79	-	-
Total	35.63	30.56 – 41.26	16.83	13.78 – 20.33	26.04	16.92-38.20
Injury						
Wrist and Hand	2.89	1.62 - 4.77	0.89	0.33-1.94	2.89	0.59-8.45
Knee/lower leg	1.96	0.94 - 3.61	1.06	0.43 – 2.18	0	0
Head/Eye	1.36	0.49 - 2.96	0.35	0.04-1.26	1.13	0.03 – 6.30
Lower back/lumbar spine	0.93	0.25-2.37	0.54	0.11 – 1.56	1.16	0.03 – 6.44
Thorax/neck	0.56	0.11 – 1.63	0.57	0.16 – 1.46	0	0
Skin burn	0.19	0.004 – 1.03	0.57	0.16 – 1.46	0.93	0.02 – 5.16
Upper arm/shoulder	0.25	0.006 – 1.38	0.38	0.05 – 1.37	-	-
Elbow/forearm	0.56	0.11-1.63	-	-	0.93	0.02 – 5.16
Total	8.69	6.29-11.69	4.35	2.89-6.29	7.07	2.85-14.53

IRR was determined to assess the differences in the disease and injury rates between deck, engine, and galley workers. Deck workers had significantly higher rates of cardiovascular, dermatological, respiratory, and musculoskeletal disorders when compared to engine workers. Also, deck workers had 3.25 times higher rates of wrist and hand injuries than engine workers (Table 4).

Table 4. Differences in rates of seafarer diseases and injuries between worksite groups over the four years study period (n = 379)

Medical events	Deck vs. Engine		Deck vs. Galley		Engine vs. Galley	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Diseases						
Gastrointestinal	1.87	1.06 – 3.33	1.09	0.45 – 3.21	0.59	0.23 – 1.77
Musculoskeletal	2.14	1.13 – 4.17	1.12	0.43 – 3.72	0.52	0.19 – 1.81
Cardiovascular	3.25	1.51 – 7.58	1.25	0.43 – 4,94	0.39	0.11 – 1.68
Non-specific	1.80	0.83 – 3.99	3.59	0.57 - 149	1.99	0.30 – 84.9
Respiratory	2.60	1.11 – 6.57	3.59	0.56 – 149	1.38	0.19 – 60.7
Dermatological	4.33	1.68 – 13	1.0	0.34 – 4.03	0.23	0.05 – 1.11
Genitourinary	1.59	0.59 – 4.34	2.2	0.31 - 94	1.38	0.19 – 60.7

Eye/Adnexa	1.14	0.35 – 3.59	1.40	0.18 - 63	1.23	0.17 - 55
Infectious and parasitic	1.63	0.35 – 8.19	-	-	-	-
Ear/Mastoid	0.32	0.006 – 3.28	0.2	0.002 – 15.6	0.61	0.06 – 30.3
Neurological	2.6	0.14 - 153	0.4	0.02 – 23.5	0.15	0.001 - 12
Mental/behavioral	3.9	0.31 - 204	-	-	-	-
Total	2.11	1.65 – 2.72	1.37	0.89 – 2.17	0.65	0.41 – 1.04
Injury						
Wrist and Hand	3.25	1.19 – 10.23	1.00	0.28 – 5.39	0.31	0.06 – 1.90
Knee/lower leg	1.86	0.64 – 5.75	-	-	-	-
Head/Eye	3.9	0.69 – 39.5	1.2	0.15 - 55	0.31	0.02 - 18
Lower back/lumbar spine	1.73	0.29 – 11.8	0.80	0.08 – 39.7	0.46	0.04 - 24
Thorax/neck	0.98	0.14 – 5.76	-	-	-	-
Skin burn	0.33	0.01 – 3.28	0.2	0.003 – 15.7	0.62	0.06 – 30.3
Upper arm/shoulder	0.65	0.01 – 12.5	-	-	-	-
Total	1.99	1.21 – 3.34	1.23	0.55 – 3.24	0.62	0.26 – 1.67

4. DISCUSSION

This descriptive epidemiological study was mainly designed to quantify the incidence rates of injuries and diseases among seafarers by worksite and rank groups. We have found that across all worksites, the rates of overall diseases were four times higher than the corresponding total injuries rates. A similar finding was reported from a study conducted in the USA[15], which reported 2 to 3 times total illnesses higher in the worksites than overall injuries. The overall disease rate was 25 per 1,000 seafarer-year during the study period. The most frequent causes of illnesses on board were gastrointestinal, musculoskeletal, and cardiovascular disorders. The majority of gastrointestinal (63%) cases were gastroesophageal reflux (GERD), esophagitis, ulcers, gastritis, hernia, and appendicitis. Lower back disorders (73% of all musculoskeletal disorders) and angina pectoris (39.2% of all CVD diagnoses) were the most frequently reported musculoskeletal and cardiovascular disorders, respectively. This might be related to the lack of fresh food in the diet of seafarers, poor hygiene, and problems in food handling that may increase the risk of digestive system diseases.

Cardiovascular diseases might be related to work related-stress, lifestyle, in particular a diet rich in fat, drinking, smoking, and physical inactivity. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight

and obese, respectively[22]. This finding suggests that in seafarer's CVD risk factors are higher compared to ashore workers. On the other hand, cardiovascular diseases and metabolic disorders are stress-related diseases[23]. Seafarers have high work-related stressors when compared to ashore workers[20] because their work is characterized by long working hours, often time-pressure, prolonged isolation from family, and hectic activity. Various studies have reported that work-related stress has long been considered a contributing factor in the development of coronary heart disease[24], musculoskeletal problems[25], and gastrointestinal disorders[26]. Similar findings were reported in a Japanese study[27], which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not consistent with the study conducted in the USA[3], which reported that dental (26%), respiratory (19%), and dermatological (14%) disorders were in the order the pathologies occurring most often among sailing seafarers. Our work has also demonstrated that non-officers had 1.45 times higher risk for total diseases, and 2.12, 2.25, and 3.66 times significantly higher risk for gastrointestinal, musculoskeletal, and dermatological disorders, respectively than officers.

Deck workers had 2.11 times higher risk for total diseases compared to engine workers. In particular, deck workers had 4.33, 3.25, 2.60, 2.14, and 1.87 times higher risk for dermatological, cardiovascular, respiratory, musculoskeletal, and gastrointestinal disorders, respectively, when compared to engine workers. Cardiovascular pathologies might be due to work-related stress because deck workers have high work-related stress due to sleep interruption, high job demands, night shift work, and intense activity than engine workers. Long working hours are contributing factors to work-related stress, and it is logical to expect an association between long hours and cardiovascular disorders[28]. The relationship between stress and coronary heart disease are considered to be linked to multiple and protracted increases in heart rate and blood pressure resulting from neuroendocrine activation[29,30]. Other studies have reported that work-related stress can increase the cardiovascular risk of workers [31–33].

Dermatological disorders might result in the exposure of skin to risk factors in the workplace. Seafaring is a risky activity and characterized by exposure to different skin risk factors such as seawater, humidity, solar radiation, and others[34,35]. Deck crew are frequently engaged in maintenance, repair, loading, painting activities, and often exposed to chemicals, UV radiation, and other skin risk factors[36,37].

The total injury rate was 6.31 per 1,000 seafarer-year over four years' study period. The observation that injuries occurred more often in younger seafarers suggests that a lack of

experience and of attention in performing the required tasks may be a cause of injuries. Nearly 30% of injuries occurred in the wrist and hand, followed by knee and lower leg (21.20%). Our results agree with the study conducted in the Danish-flagged merchant fleet[18], which reported that 36% and 18% of upper and lower limb injuries, respectively. Moreover, this study revealed that non-officers had 1.75 times higher risk for injuries compared to officers. These findings are agree with previous studies reporting that non-officer have nearly 1.60 times higher risk for injuries compared to officers [17,3,38]. Maritime officers, including the captain, have high-level responsibilities such as navigation, planning, organization of loading and unloading operations, and ship controls[19,39]. Non-officers are involved in other tasks occurring during a voyage such as mooring, cleaning the ship, repairing broken lines and ropes, operating machinery like cranes and derricks, and also perform steering of the ship at sea[20,39]. The non-officer work is also physically challenging[19,20,39] and must be carried out regardless of weather conditions. This could explain why non-officers have a higher risk of injuries than officers.

The present study has shown that the deck workers had higher rates of overall injuries compared to engine and galley workers. These results are consistent with those of the study conducted in the USA[15]. Similarly, deck workers had a significantly higher risk for wrist and hand injuries compared to engine workers. A study conducted in Danish Fleet seafarers[38] reported that deck workers had a relatively low risk for injuries compared to machine (engine) workers. Deck workers, particularly deck ratings, perform physical works such as mooring and unmooring the ship, loading, and unloading cargo[39].

Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than engine workers because they are engaged in the surveillance system with frequent irregular operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs and maintenance work in the deck area[19,20,39]. Hence, night shift work, long working hours, short average sleep time, and physical stress are important factors contributing to the high rates of injuries/accidents at sea[10,19,28,40].

Strengths and limitations

Most of the previous studies on pathologies and accidents among seafarers were focused on the number of cases occurring without a specific epidemiological analysis of the phenomenon. This study measured the incidence of disease and injury for rank and occupation groups by estimating the seafarer population of underlying at risk in the rank and workplace categories. Also, our study demonstrated the incidence rate ratio (IRR) to compare the risk between rank

and occupation groups. Limits of this work are in the use of the estimated at-risk seafarer population in the analysis due to the lack of information on actual at-risk seafarer population. As a result, the incidence rate may be underestimated or overestimated. Moreover, we have not measured injury and disease incidence rates by age, gender, work experience, and nationality due to a lack of these information on the total at-risk seafarer population.

CONCLUSION

In general, non-officers and deck workers had a higher risk for diseases and injuries over the four years of the study period. Non-officers had a significantly higher risk for gastrointestinal, musculoskeletal, and dermatological disorders and knee and lower leg injuries. Deck officers had a significantly higher risk for dermatological, cardiovascular, musculoskeletal, respiratory and gastrointestinal disorders, and wrist and hand injuries. Gastrointestinal, musculoskeletal, and cardiovascular disorders were the most frequent health problems onboard ships.

In terms of prevention, improvement in occupational safety, and the use of protective equipment and training on work safety procedures could minimize the risk of injuries. A comprehensive risk assessment, including the identification of hazards, evaluation of the frequency of different injuries and diseases, and more efforts in specific training programs will help in reducing the occurrence of occupational injuries onboard ships. The availability of telemedicine devices[41], and of systems for quick diagnosis of transmittable diseases in isolated places such as POCRAMÉ[42] will provide a relevant contribution to health protection of seafarers. Regular health checks for non-communicable diseases, lifestyle changes such as a healthy diet and regular exercise could reduce the incidence of CVD. Improved quality of food provision, catering, proper hygiene, and handling of food may reduce gastrointestinal disorders. More attention in training and education and following appropriate lifestyle changes can contribute to improving health onboard ships are the take-home lessons that we can get from epidemiology. To sum up, the availability of epidemiological data on the occurrence of diseases and injuries among seafarers could increase the awareness of factors affecting health on board ships moving in the direction of "prevention is better than cure," one of the main goals of modern medicine.

Contributors

GG.S.: designed study, performed analysis, methodology, interpreted the data and results, and drafted manuscript. M.D: extracted data and assisted with the preparation of manuscript. G.B.: contributed to the data collection. MA.S: interpreted the data and involved in the

preparation of the manuscript. F.A: guided, edited, reviewed, and approved the study. All authors approved the final manuscript.

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Conflict of interests

The authors declared that they have no conflict of interest.

Ethical approval

The study has been reviewed and approved by the Scientific/Ethic Committee of the C.I.R.M Foundation.

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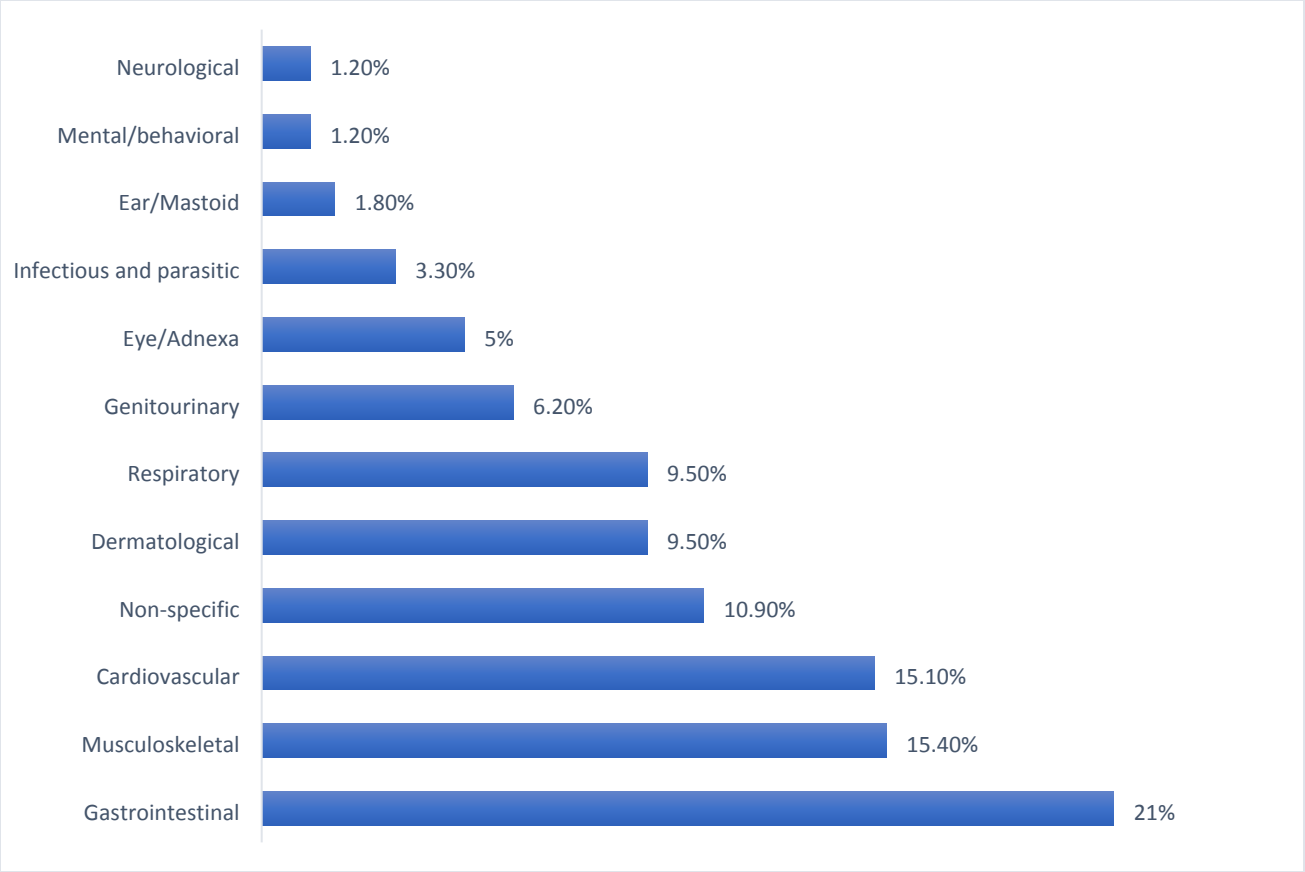

Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n = 338)

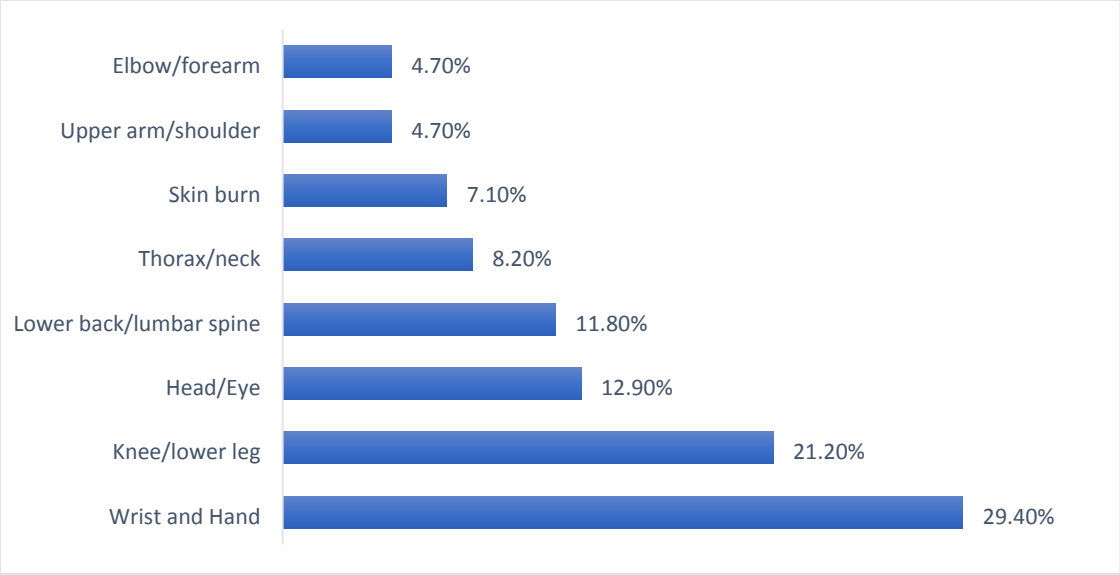

Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n = 85)

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Incidence of occupational injuries and diseases among seafarers

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Abstract

Objectives: Workers at sea have high mortality, injuries, and illnesses, and work in a hazardous environment compared to ashore workers. The present study was designed to measure the incidence of diseases and occupational injuries among seafarers and quantify the contribution of differences in rank and job onboard on seafarers' illnesses and injuries rates.

Methods: A retrospective study was employed. This study's data were based on contacts (n = 423) for medical requests from CMA CGM container ships to the International Radio Medical Center (C.I.R.M.) in Rome from 2016 to 2019, supplemented by data on the estimated total at-risk seafarer population on container ships (n =13,475) over the study period. The outcome measures were the distribution of Injuries by anatomic location and types of diseases across seafarers' ranks and worksites. We determined the incidence rate and incidence rate ratio (IRR) with a 95% confidence interval (CI).

Results: The total disease rate was 25 per 1,000 seafarer-years, and the overall injury rate was 6.31 per 1,000 seafarer-years over the four years study period. Non-officers were more likely than officers to have gastrointestinal [IRR: 2.12 (95% CI) = 1.13 – 4.26], dermatological [IRR: 3.66 (95% CI) = 1.27 – 14.42] and musculoskeletal [IRR: 2.25 (95% CI) = 1.11–5.05] disorders onboard container ships. Deck workers were more likely than engine workers to be injured in the wrist and hand (IRR:3.25 (95% CI) = 1.19 – 10.23).

Conclusions: Rates of reported injury and disease were significantly higher among non-officers than officers; thus, this study suggests the need for rank-specific preventative measures. Future studies should consider risk factors for injury and illness among seafarers in order to propose further preventive measures.

Keywords: Epidemiology, Injury, Disease, Seafarer, Rank, Occupation

Strengths and limitations of this study

- The first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarer's onboard container ships.
- This study measured the incidence rates and Incidence rate ratios of injury and disease by rank and worksite of seafarers based on contacts from onboard container ships to TMAS.
- The estimated at-risk seafarer population was used in the analysis due to the lack of information on the actual at-risk seafarer population.

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively[1]. It is estimated that nearly 65,000 deep-sea merchant ships operate worldwide, carrying more than 1.6 million sailing seafarers[1,2].

In general, work onboard ships are broadly grouped by working areas, including the deck, engine, and galley[3]. Shipping is one of the most widespread transportation systems, and more than 88% of the world's trade utilizes it[4,5]. Workers at sea have high mortality, injuries, and illnesses rate compared to ashore workers[5]. Sailing seafarers have a one in eleven chance of being injured on duty on board [6], and sometimes physical injuries can be acute and a primary cause of disability. Different studies have reported higher mortality and morbidity rates onboard merchant ships when compared to the land occupation. For instance, a study conducted on the British merchant fleet reported that between 2003 to 2012, the fatal accident rate in shipping was 21 times higher than that in the general British workforce, 4.7 times higher than that in the construction industry, and 13 times higher than in manufacturing[7]. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore[8]. Moreover, seafarers working on board of British merchant ships had 23.9 times higher risk of mortality due to accidents at work than all workers in Great Britain[9]. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km[10].

Identifying the potential area of incidents and assessing the probability of the occurrence of occupational medical events may assure the availability of treatment and the development of prevention strategies to reduce the rate of diseases and/or injuries among seafarers and to improve health outcomes[11–13]. Unfortunately, due to the scarcity of evidence-based information on the incidence of occupational diseases and injuries onboard ships, preventive measures in the maritime environment received less attention than other working activities [14]. On the other hand, determinants of onboard merchant ship illnesses, injuries, disability, and fatalities, remain not adequately studied due to the not easy access of seafarer's medical data[3,13,15]. Previous studies have reported that non-officers have a higher risk for diseases and injuries compared to officers[3,15–18], but most of these studies considered only occupational groups.

The exposure to the work-related risk of officers and non-officers working in different ship areas such as deck, engine, and galley is not similar because they attend different duties in different working hours[19]. For instance, workers in the engine room are exposed to work-

related risks such as noise, vibration, and heat or pollutants during their working hours[19,20]. In contrast, people working in the deck, as well as in the galley, are potentially exposed to different work-related risks[19]. Because of the different areas of activity and associated burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study on the incidence rates of injury and disease by rank and worksite of seafarers would provide information for prevention strategies such as resource allocation, prioritizing training areas, improving the medicine chests on board, and access to telemedicine consultation to reduce injury and disease at the workplace.

The present study aimed to analyze the incidence rates of reported occupational diseases and injuries among seafarers by worksite and rank groups. This work provides factual information on the rate of illnesses and injuries between the worksite group as well as the rank. The results obtained can be used to prioritize occupational health risks and guide the development of preventative measures onboard container ships.

2. METHODS

2.1. Study design, data source, and collection procedure

We employed a retrospective study design and received data from the Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M. is the Italian Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than 100,000 seafarers onboard ships [21]. CMA CGM S.A. is a French container transport and shipping company. It is a leading shipping group globally, using 200 shipping routes between 420 ports in 150 different countries. In this particular study, the data source we used was reported diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome. CMA CGM S.A. shipping company made a contractual agreement with C.I.R.M. in January 2016 to identify new approaches to provide high-quality telemedical assistance for seafarers. In view of this agreement, data provided for medical assistance on the company's board ships are more detailed and, therefore, can be used for a basic epidemiological analysis.

Work-related diseases are illnesses predominantly due to physical, chemical, and biological factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M. database according to the World Health Organization (WHO) International Classification of Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden, unexpected, and unwanted forceful event due to an external cause's onboard ships. In the

C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version (chapter XIX, S00-S99, and T00-T98).

The classification of both illnesses and occupational injuries was made according to the prompt diagnosis and recorded medical datasets in the C.I.R.M. database. The attributes included in the database were age, gender, rank, working site, type of vessel, means of contacts, days, months, and years of diagnosis. Disease and injury diagnosis affected body parts, and ICD 10 for both diseases and injuries were included in the dataset. For the analysis of the incidence of illnesses and injuries, the rank and worksite groups were the parameters considered.

An estimated total number of at-risk seafarer population was calculated by multiplying the number of vessels during the study period by the average number of crew members per vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an average size of 20 crew members per ship[3]. The CMA CGM shipping company handles only container ships, with an average of 25 crew members per ship. Regarding rank distribution per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck workers, thirteen engine workers and two galleys (catering) workers are in service per vessel. The average number of the crew size, their rank as well as worksite distribution per large vessel based on the knowledge of industry norm were calculated.

The number of CMA CGM container ships contracted over four years, from January 2016 to December 31, 2019, was 539. An estimated number of the total at-risk seafarer population for worksite and rank was determined by multiplying the total number of vessels over four years by occupation and rank distribution per ship. The total number of seafarers at risk was adjusted proportionally to the number of seafarers in the dataset for whom information on occupation and rank was available. Then, worksite and rank specific incidence rates were calculated by dividing the number of cases by the total at-risk seafarer population for each worksite and rank over four years. Incidence rate ratio (IRR) and 95% confidence interval (CI) were calculated to compare the injuries and diseases rates by seafarer's rank and worksite. The outcome of rates was expressed as per 1,000 seafarer-years. Seafarer-year is defined as the number of crew members per ship multiplied by the number of vessels each year. Descriptive analysis of seafarer's demographic variables, including age, rank, and worksite, was done to evaluate the distribution of reported occupational injuries and diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley). The worksite was also categorized into three groups, including the deck, engine, and galley. The Chi-square or Fisher's exact test was used to determine distributional

differences in rank and worksite groups. A two-tailed P <0.05 was considered statistically significant. The STATA software version 15 was used for data analysis.

2.2. Patient and public involvement

Patients and public were not involved in the study

3. RESULTS

Overall, 423 patients were assisted by the C.I.R.M. aboard container ships during the four-year study period. Of these, 338 (80%) and 85 (20%) were diseases and injuries, respectively. However, 11% (37) of the total number of patients with the disease and 8% (7) of the injured patients were unknown as to rank and worksite. The mean age (SD) of seafarers with illnesses and injuries was 40.37 + 12.52 years and 38.39 + 12.88 years, respectively. The total disease rate was 25 per 1000 seafarer-years. Injury and disease incidence rates for non-officer and officer were significantly differed, as shown in Table 1. In column 5 of Table 1, we reported only the incidence rate ratios that were statistically significant (p <0.05). As a result, non-officers were more likely than officers to be injured (IRR = 1.75) and to have the disease (IRR = 1.45). Deck workers are almost 2 times more likely than engine workers to be injured (p <0.001) (Table 1).

Table 1. Number of cases, seafarer-years, incidence rates, and incidence rate ratios of injury and disease by rank and worksite of seafarers from 2016 to 2019.

Variable	Injury (n = 78)	Seafarer-years	Injury incidence rate (per 1000 seafarer-years	Injury Rate ratio (95% CI)
Total	78	12,365	6.31	N/A
Rank				
Officer	19	4,451	4.27	1
Non-officer	59	7,914	7.45	**1.75** (1.75 – 3.10)*
Worksite				
Deck	43	4,946	8.69	**1.99** (1.21 – 3.34)**
Engine	28	6,430	4.35	1
Galley	7	989	7.07	
	Disease(n=301)	Seafarer-years	Disease incidence rate (per 1000 seafarer-years	Disease Rate ratio (95% CI)
Total	301	12,000	25	N/A
Rank				
Officer	84	4320	19.44	1
Non-officer	217	7680	28.25	**1.45** (1.12 – 1.89)**
Worksite				
Deck	171	4,800	35.63	**2.12** (1.69 – 2.80)**
Engine	105	6,240	16.83	1
Galley	25	960	26	

Significant at *p <0.01, **P<0.001, Abbreviation: N/A , not applicable

The most frequent causes of illnesses onboard ships were gastrointestinal disorders (n = 71, 21%) followed by musculoskeletal (n = 52, 15.40%) and cardiovascular diseases (n = 51, 15.10%) (Figure 1). In general, out of the 85 injuries, 29.40% were wrist and hand injuries, 21.20% were knee/lower leg injuries, 12.90% were head/eye injuries, 11.80% were lower back/lumbar spine injuries, 8.2% were thorax/neck injuries (Figure 2).

Rank-specific incidence rates of occupational injuries and diseases

Gastrointestinal diseases were the most common disorders for officers (IR = 3.1 per 1000 seafarer-years) and non-officers (IR = 6.51 per 1000 seafarer-years), as presented in Table 2. The most common injuries for non-officer was wrist/hand (1.93 per 1000 seafarer-years) and knee/lower leg (1.84 per 1000 seafarer-years). The incidence rate ratio (IRR) for non-officers' versus officers was determined and reported in Table 2. As a result, non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. Concerning injuries, non-officers were more likely than officers to be injured in the knee or lower leg (IRR = 4.21) (Table 2).

Table 2. Incidence Rate of diseases and occupational injuries by the seafarer rank from 2016 to 2019 (n = 379)

Medical events	Officer		Non-officer		IRR[a]	95% CI
	Rate	95% CI	Rate	95% CI		
Disease types						
Gastrointestinal	3.1	1.64 - 5.24	6.51	4.82 - 8.59	2.12	1.13-4.26*
Musculoskeletal	2.14	1.03 - 3.94	4.82	3.45 - 6.56	2.25	1.11-5.05*
Cardiovascular	2.69	1.29 - 4.95	4.39	2.95 - 6.31	1.63	0.77 – 3.75
Non-specific	2.86	1.47 - 4.99	2.68	1.64 - 4.14	0.94	0.44-2.10
Respiratory	2.59	1.29 - 4.63	2.25	1.31 - 3.60	0.87	0.38 – 2.05
Dermatological	0.88	0.24 - 2.25	3.22	2.10 - 4.71	3.66	1.27-14.42*
Genitourinary	2.06	0.99 - 3.78	1.27	0.64 - 2.28	0.62	0.24-1.63
Eye/Adnexa	1.31	0.48 - 2.86	1.23	0.59 - 2.27	0.94	0.31-3.14
Infectious and parasitic	1.26	0.4 - 2.94	0.57	0.15 - 1.45	0.45	0.09-2.09
Ear/Mastoid	0.41	0.05 - 1.49	0.46	0.13 - 1.19	1.13	0.16-12.44
Neurological[b]	—	—	0.46	0.13 - 1.19	—	—
Mental/behavioral	0.21	0.005 - 1.14	0.35	0.07 - 1.02	1.69	0.14-88.59
Injury Location						

Wrist/Hand	1.72	0.74 - 3.38	1.93	1.11 - 3.14	1.13	0.45 – 3.03
Knee/lower leg	0.44	0.05 - 1.57	1.84	1.03 – 3.03	4.20	1.01 – 38.01*
Head/Eye	0.76	0.16 - 2.21	0.85	0.31 - 1.85	1.13	0.24-6.95
Lower back/lumbar spine	0.77	0.16 - 2.25	0.73	0.24 - 1.69	0.94	0.18-6.07
Thorax/neck	0.21	0.005 - 1.14	0.69	0.25 - 1.51	3.37	0.41-155
Skin burn	0.21	0.005 - 1.14	0.58	0.19 - 1.35	2.81	0.31-133
Upper arm/shoulder	0.27	0.006 - 1.53	0.46	0.09 - 1.35	1.69	0.14-88.6
Elbow/forearm[b]	—	—	0.46	0.13 - 1.18	—	—

**IRR significant at p-value <0.05*

[a]Incidence rate ratio (IRR) and calculated as the rate of non-officer/rate of officer

[b]Dashes indicate the comparison that was not performed.

Worksite-specific incidence rates of occupational injuries and diseases

Table 3 summarizes the rates of illnesses and injuries per seafarer worksite groups. Consequently, gastrointestinal (IR = 7.01), cardiovascular (IR = 6.06) and musculoskeletal (IR = 5.40) diseases were the most common disorders for deck workers. Musculoskeletal disorders (IR =2.52) were the second most common diseases for engine workers. Wrist/hand injuries (IR = 2.89) were the most common injury for both deck and galley workers, while knee/lower leg injuries (IR = 1.06) were for engine workers (Table 3).

Table 3. Incidence rates of occupational injury and disease by seafarer's worksite from 2016 to 2019 (n= 379)

Medical events	Deck		Engine		Galley	
	Rate	95% CI	Rate	95% CI	Rate	95% CI
Disease types						
Gastrointestinal	7.01	4.83 - 9.83	3.76	2.38 - 5.63	6.37	2.34-13.83
Musculoskeletal	5.40	3.59 - 7.79	2.52	1.47 - 4.04	4.82	1.56-11.22
Cardiovascular	6.06	3.93 – 8.94	1.86	0.89 – 3.43	4.85	1.32-12.38
Non-specific	3.86	2.29 – 6.09	2.15	1.14-3.66	1.07	0.03 – 5.96
Respiratory	3.82	2.26 – 6.02	1.46	0.67 – 2.78	1.06	0.03 – 5.89
Dermatological	3.96	2.42 – 6.11	0.91	0.34 – 1.98	3.96	1.08 – 10.09
Genitourinary	2.04	1.02 – 3.65	1.28	0.59 – 2.43	0.93	0.02 – 5.16
Eye/Adnexa	1.38	0.56 – 2.84	1.21	0.52 – 2.39	0.98	0.03 – 5.48

Infectious and parasitic[b]	1.13	0.37 – 2.64	0.69	0.19 – 1.79	—	—
Ear/Mastoid	0.19	0.004 – 1.03	0.57	0.16 – 1.46	10.93	0.02 – 5.16
Neurological	0.37	0.05 – 1.34	0.14	0.003 – 0.79	0.93	0.02 – 5.16
Mental/behavioral[b]	0.56	0.12 – 1.62	0.14	0.003 – 0.79	—	—
Injury Location						
Wrist/Hand	2.89	1.62 - 4.77	0.89	0.33-1.94	2.89	0.59-8.45
Knee/lower leg[b]	1.96	0.94 - 3.61	1.06	0.43 – 2.18	—	—
Head/Eye	1.36	0.49 - 2.96	0.35	0.04-1.26	1.13	0.03 – 6.30
Lower back/lumbar spine	0.93	0.25-2.37	0.54	0.11 – 1.56	1.16	0.03 – 6.44
Thorax/neck[b]	0.56	0.11 – 1.63	0.57	0.16 – 1.46	—	—
Skin burn	0.19	0.004 – 1.03	0.57	0.16 – 1.46	0.93	0.02 – 5.16
Upper arm/shoulder[b]	0.25	0.006 – 1.38	0.38	0.05 – 1.37	—	—
Elbow/forearm[b]	0.56	0.11-1.63	—	—	0.93	0.02 – 5.16

[b]*Dashes indicate the comparison that was not performed*

The IRRs for deck workers versus engine workers', deck workers versus galley workers', and engine workers versus galley workers were calculated and presented in Table 4. As a result, deck workers were more likely than engine workers to have gastrointestinal (IRR = 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR = 2.14) disorders. Also, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25)(Table 4).

Table 4. Incidence rate ratios (IRR) and 95% confidence intervals (95% CI) of occupational injury and disease stratified by seafarers' worksite from 2016 to 2019 (n = 379)

Medical events	Deck vs. Engine		Deck vs. Galley		Engine vs. Galley	
	IRR	95% CI	IRR	95% CI	IRR	95% CI
Disease types						
Gastrointestinal	1.86	1.06 – 3.33*	1.09	0.45 – 3.21	0.59	0.23 – 1.77
Musculoskeletal	2.14	1.13 – 4.17*	1.12	0.43 – 3.72	0.52	0.19 – 1.81
Cardiovascular	3.26	1.51 – 7.58*	1.25	0.43 – 4,94	0.39	0.11 – 1.68
Non-specific	1.80	0.83 – 3.99	3.59	0.57 - 149	1.99	0.30 – 84.9
Respiratory	2.62	1.11 – 6.57*	3.59	0.56 – 149	1.38	0.19 – 60.7
Dermatological	4.35	1.68 – 13*	1.0	0.34 – 4.03	0.23	0.05 – 1.11

Genitourinary	1.59	0.59 – 4.34	2.2	0.31 - 94	1.38	0.19 – 60.7
Eye/Adnexa	1.14	0.35 – 3.59	1.40	0.18 - 63	1.23	0.17 - 55
Infectious and parasitic[b]	1.63	0.35 – 8.19	—	—	—	—
Ear/Mastoid	0.32	0.006 – 3.28	0.2	0.002 – 15.6	0.61	0.06 – 30.3
Neurological	2.6	0.14 - 153	0.4	0.02 – 23.5	0.15	0.001 - 12
Mental/behavioral[b]	3.9	0.31 - 204	—	—	—	—
Injury Location						
Wrist/Hand	3.25	1.19 – 10.23*	1.00	0.28 – 5.39	0.31	0.06 – 1.90
Knee/lower leg[b]	1.86	0.64 – 5.75	—	—	—	—
Head/Eye	3.9	0.69 – 39.5	1.2	0.15 - 55	0.31	0.02 - 18
Lower back/lumbar spine	1.73	0.29 – 11.8	0.80	0.08 – 39.7	0.46	0.04 - 24
Thorax/neck[b]	0.98	0.14 – 5.76	—	—	—	—
Skin burn	0.33	0.01 – 3.28	0.2	0.003 – 15.7	0.62	0.06 – 30.3
Upper arm/shoulder[b]	0.65	0.01 – 12.5	—	—	—	—

**IRR significant at p-value <0.05*

[b]Dashes indicate the comparison that was not performed.

4. DISCUSSION

This descriptive epidemiological study was mainly designed to quantify the incidence rates of reported injuries and diseases among seafarers by worksite and rank groups. The injury and illness rates measured were based on the contacts from onboard container ships to the Telemedical Maritime Assistance Service (TMAS) in Rome. Any contact for medical requests from ships to the C.I.R.M. with injuries or cases of illness with important patient data, including age, sex, job, rank, the nationality of the patient, ship flag, ship name, date of medical event that occurred, anatomic location of the injury, diagnosis, treatment provided, the patient follow-up schedule and other relevant information are registered in the database. Hence, we got access to injuries and diseases with seafarers' rank and job from the datasets. We have found that the rates of overall reported diseases were four times higher than the corresponding total reported injuries rates across all worksites. A similar finding was reported from a study conducted in the USA[15], which reported 2 to 3 times total illnesses higher in the worksites than overall injuries. The overall reported disease rate was 25 per 1,000 seafarer-year during the study period. The disease rate for non-officers and officers were significantly differed [IRR: 1.45 (95% CI) = 1.12 – 1.89]. This study reported that the most common causes

of illnesses on board were gastrointestinal (21%), musculoskeletal (15.40%), and cardiovascular disorders (15.10%). Similar findings were reported in a Japanese study[22], which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not consistent with the study conducted in the USA[3], which reported that dental (26%), respiratory (19%), and dermatological (14%) disorders were in the order the pathologies occurring most often among sailing seafarers.

The majority of gastrointestinal (63%) cases were gastroesophageal reflux (GERD), esophagitis, ulcers, gastritis, hernia, and appendicitis. This might be related to the lack of fresh food in seafarers' diet and problems in food handling that may increase the risk of digestive system diseases. Lower back disorders (73% of all musculoskeletal disorders) and angina pectoris (39.2% of all CVD diagnoses) were the most frequently reported musculoskeletal and cardiovascular disorders, respectively. As for cardiovascular disorders, it could be related to work-related stress, lifestyle, especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight and obese, respectively[23]. This finding suggests that in seafarer's CVD risk factors are higher compared to ashore workers. On the other hand, cardiovascular diseases and metabolic disorders are stress-related diseases[24].

Our work has also demonstrated that non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. This might be due to work-related stress because maritime officers, including the captain, have high-level responsibilities such as navigation, planning, organization of loading and unloading operations, and ship controls[19,25]. Non-officers are involved in other tasks occurring during a voyage and their work is physically more demanding and stressful than officers. In general, seafarers have high work-related stressors when compared to ashore workers[20] because their work is characterized by long working hours, often time-pressure, prolonged isolation from family, and hectic activity. Various studies have reported that work-related stress has long been considered a contributing factor in the development of musculoskeletal problems[26] and gastrointestinal disorders[27].

Gastrointestinal (IR = 7.01), cardiovascular (IR = 6.06) and musculoskeletal (IR = 5.40) diseases were the most common disorders for deck workers. Similarly, deck workers were more likely than engine workers to have gastrointestinal (IRR = 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR =

2.14) disorders. Cardiovascular pathologies might be due to work-related stress because deck workers have high work-related stress due to sleep interruption, high job demands, night shift work, and intense activity than engine workers. A study reported that work related stress was a risk factor for cardiovascular diseases[28]. Long working hours are contributing factors to work-related stress, and it is logical to expect an association between long hours and cardiovascular disorders[29,30]. Studies have also shown that night shift work had adverse effects on health and risk factors for the development of chronic diseases such as cardiovascular diseases[19,31,32]. The relationship between stress and coronary heart disease are considered to be linked to multiple and protracted increases in heart rate and blood pressure resulting from neuroendocrine activation[33–36]. Other studies have reported that work-related stress can increase the cardiovascular risk of workers [37–39]. As for dermatological disorders, it might result in skin exposure to risk factors in the workplace. Seafaring is a risky activity characterized by exposure to different skin risk factors such as seawater, humidity, solar radiation, and others[40,41]. Deck crews are frequently engaged in maintenance, repair, loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk factors[42,43].

The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period. The injury rate for non-officers and officers were significantly differed [IRR: $1.75\ (95\%\ \mathrm{CI}) = 1.75 - 3.10$]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and lower leg (21.20%). Our results agree with the study conducted in the Danish-flagged merchant fleet[18], which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover, this study revealed that non-officers were more likely than officers to be injured (IRR = 1.75). This finding was in agreement with the previous studies [17,3,44]. Non-officer work is characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating machinery such as cranes and drilling towers, and steering the ship at sea[20,25]. The non-officer work is also physically challenging[19,20,25] and must be carried out regardless of weather conditions. This could explain why non-officers have a higher rate of injuries than officers.

The present study has shown that the deck workers had higher rates of overall reported injuries (IR = 8.69) compared to the engine (IR = 4.35) and galley (IR = 7.07) workers. These results are consistent with those of the study conducted in the USA[15]. We found that the injury rate for deck workers and engine workers were significantly differed [IRR: 1.99 (95% CI) $=1.21 - 3.34$]. Similarly, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25), as shown in Table 4. A study conducted in Danish Fleet seafarers[44] reported that deck workers had a relatively low risk for injuries than machine

(engine) workers. The difference could be due to methodological differences. The study on seafarers in the Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to determine incidence rates and incidence rate ratios in the Danish fleet, were not consistent with our study. Deck workers, particularly deck ratings, perform physical works such as mooring and unmooring the ship, loading, and unloading cargo[25]. Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than engine workers because they are engaged in the surveillance system with frequent irregular operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs and maintenance work in the deck area[19,20,25]. Hence, night shift work, long working hours, short average sleep time, and physical stress are important factors contributing to the high rates of injuries/accidents at sea[10,19,45,46].

Strengths and limitations

This study measured the incidence rates of reported injury and disease to TMAS for container ships. Most of the previous studies on pathologies and accidents among seafarers were focused on the number of cases. As far as we know, this study is the first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarers onboard container ships. Limitations of this study are: 1). We used an estimated average number of seafarers per ship in the analysis, although we took into account different assumptions, including the number of vessels, ships active at sea, number of crew members per ship, and the length of stay of seafarers on board for the accuracy of the estimate. Consequently, the incidence rate may be underestimated or overestimated. 2). Data from patients with injuries and cases of disease contained descriptions such as age and gender, but we had no descriptions of these data on the total at-risk seafarer population. Hence, we have not determined the rates and incidence rate ratios of the diseases and injuries by seafarers' age and sex. 3). Patient data on both injury and diagnosis were compiled according to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not on mechanisms of injury or potential physical hazards related to injured cases. As a result, we have not stratified injuries by mechanisms of injury or occupational hazards to highlight priority areas and recommend preventative measures. 4). We did not have descriptions of data types such as socio-demographic variables and another exposure status of the total seafarer population at risk. In this respect, we have not determined the risk factors for injury and disease to propose further prevention strategies. Furthermore, this study is a retrospective study and limited to the variables available in the dataset. Finally, our study is

limited to container ships and does not represent other types of ships at sea. Hence, the results do not reflect seafarers working on other types of ships.

CONCLUSION

Non-officers had significantly higher rates of overall reported diseases, specifically gastrointestinal, musculoskeletal, and dermatological disorders. Also, non-officers were more likely than officers to be injured in the knee and lower leg. Deck workers had significantly higher rates for dermatological, cardiovascular, musculoskeletal, respiratory, and gastrointestinal disorders. Deck workers were more likely than engine workers to be injured in the wrist and hand. Overall injury and disease rates for non-officers and officers significantly differed. The same is true between deck workers and engine workers. Hence, this study suggests the need for rank and work site-specific prevention strategies to reduce injury and disease rates at the workplace. Future studies should consider the risk factors for injury and disease among seafarers in order to propose further preventive measures.

Contributors

GGS.: conceived and designed the study, performed analysis, methodology, interpreted the data and results, and drafted the initial manuscript. MD: extracted data and assisted with the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and approved the study. All authors approved the final version of the manuscript.

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Conflict of interests

The authors declared that they have no conflict of interest.

Ethical approval

The study has been reviewed and approved by the Scientific/Ethics Committee of the C.I.R.M. Foundation.

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Legends of the figures

Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n = 338)

Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n = 85)

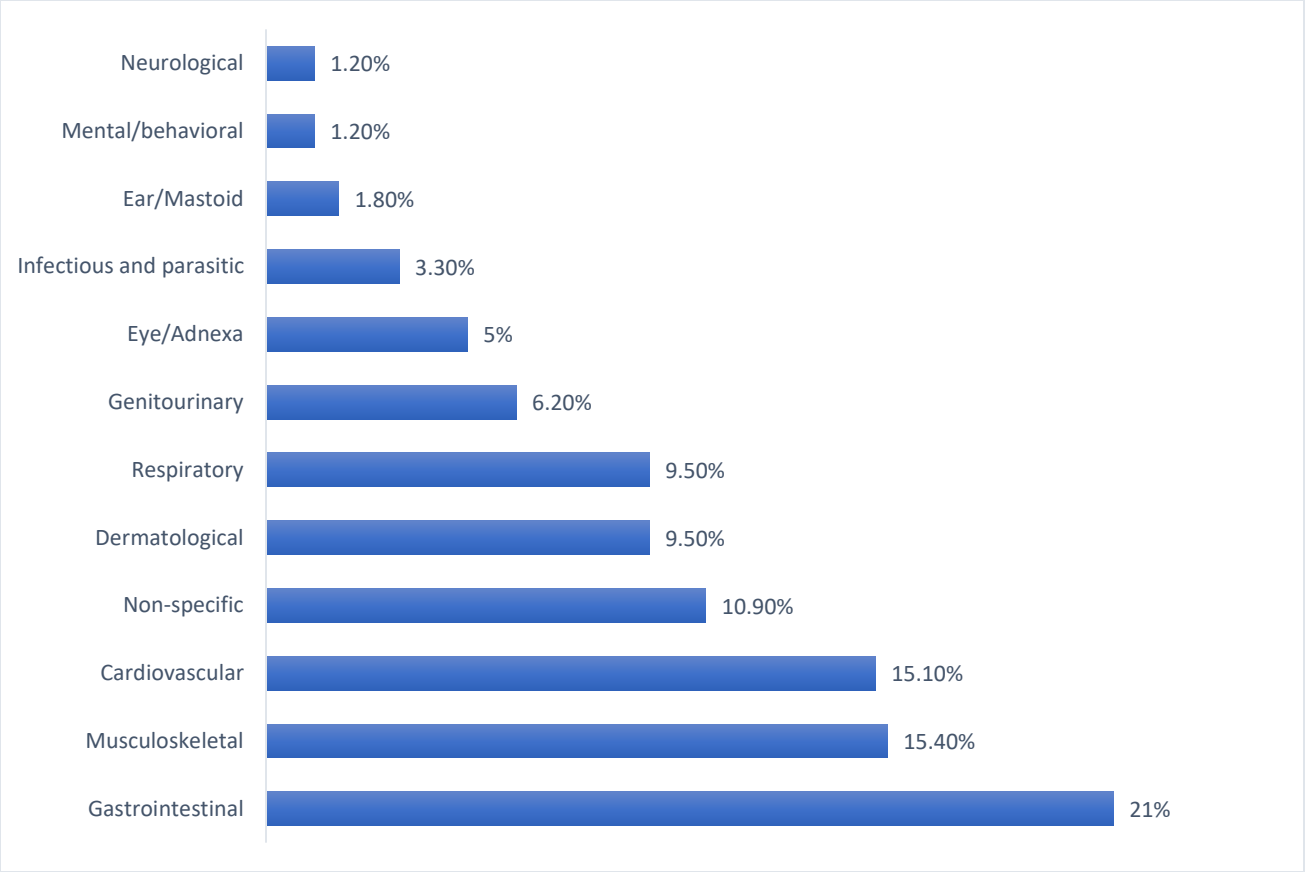

Figure 1

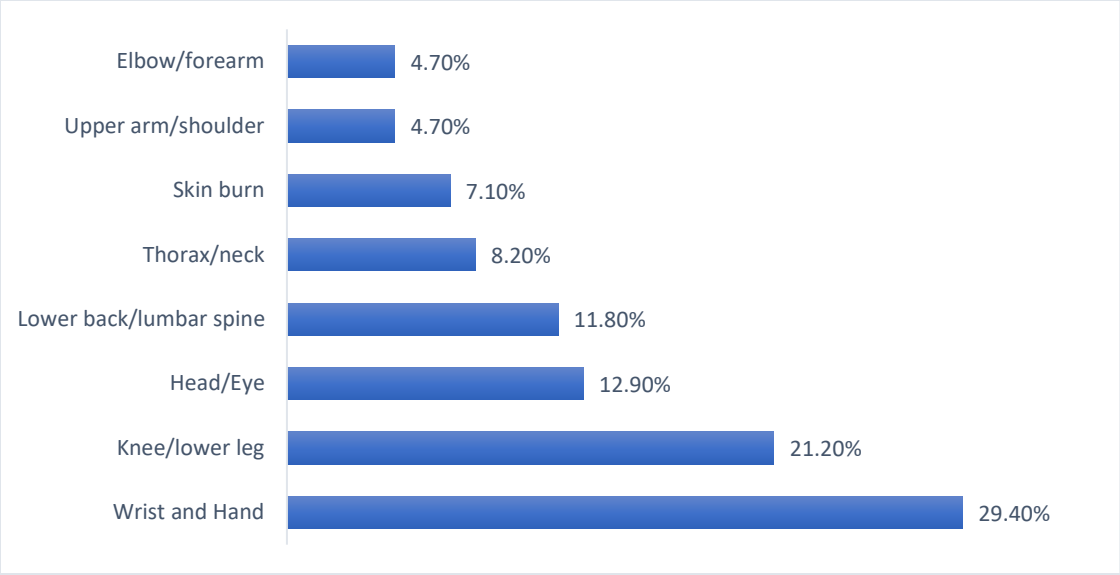

Figure 2

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5&6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7, 8, 9,10
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	11,12,13
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Incidence of occupational injuries and diseases among seafarers

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Abstract

Objectives: Workers at sea have high mortality, injuries, and illnesses, and work in a hazardous environment compared to ashore workers. The present study was designed to measure the incidence of diseases and occupational injuries among seafarers and quantify the contribution of differences in rank and job onboard on seafarers' diseases and injuries rates.

Methods: A retrospective study was employed. This study's data were based on contacts (n = 423) for medical requests from CMA CGM container ships to the International Radio Medical Center (C.I.R.M.) in Rome from 2016 to 2019, supplemented by data on the estimated total at-risk seafarer population on container ships (n =13,475) over the study period. The outcome measures were the distribution of Injuries by anatomic location and types of diseases across seafarers' ranks and worksites. We determined the incidence rate and incidence rate ratio (IRR) with a 95% confidence interval (CI).

Results: The total disease rate was 25 per 1,000 seafarer-years, and the overall injury rate was 6.31 per 1,000 seafarer-years over the four years study period. Non-officers were more likely than officers to have reported gastrointestinal [IRR: 2.12 (95% CI) = 1.13 – 4.26], dermatological [IRR: 3.66 (95% CI) = 1.27 – 14.42] and musculoskeletal [IRR: 2.25 (95% CI) = 1.11–5.05] disorders onboard container ships. Deck workers were more likely than engine workers to be injured in the wrist and hand (IRR:3.25 (95% CI) = 1.19 – 10.23).

Conclusions: Rates of reported injury and disease were significantly higher among non-officers than officers; thus, this study suggests the need for rank-specific preventative measures. Future studies should consider risk factors for injury and disease among seafarers in order to propose further preventive measures.

Keywords: Epidemiology, Injury, Disease, Seafarer, Rank, Occupation

Strengths and limitations of this study

- The first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarer's onboard container ships.
- This study measured the incidence rates and Incidence rate ratios of injury and disease by rank and worksite of seafarers based on contacts from onboard container ships to TMAS.
- The estimated at-risk seafarer population was used in the analysis due to the lack of information on the actual at-risk seafarer population.

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively[1]. It is estimated that nearly 65,000 deep-sea merchant ships operate worldwide, carrying more than 1.6 million sailing seafarers[1,2].

In general, work onboard ships are broadly grouped by working areas, including the deck, engine, and galley[3]. Shipping is one of the most widespread transportation systems, and more than 88% of the world's trade utilizes it[4,5]. Workers at sea have high mortality, injuries, and illnesses rate compared to ashore workers[5]. Sailing seafarers have a one in eleven chance of being injured on duty on board [6], and sometimes physical injuries can be acute and a primary cause of disability. Different studies have reported higher mortality and morbidity rates onboard merchant ships when compared to the land occupation. For instance, a study conducted on the British merchant fleet reported that between 2003 to 2012, the fatal accident rate in shipping was 21 times higher than that in the general British workforce, 4.7 times higher than that in the construction industry, and 13 times higher than in manufacturing[7]. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore[8]. Moreover, seafarers working on board of British merchant ships had 23.9 times higher risk of mortality due to accidents at work than all workers in Great Britain[9]. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km[10].

Identifying the potential area of incidents and assessing the probability of the occurrence of occupational medical events may assure the availability of treatment and the development of prevention strategies to reduce the rate of diseases and/or injuries among seafarers and to improve health outcomes[11–13]. Unfortunately, due to the scarcity of evidence-based information on the incidence of occupational diseases and injuries onboard ships, preventive measures in the maritime environment received less attention than other working activities [14]. On the other hand, determinants of onboard merchant ship illnesses, injuries, disability, and fatalities, remain not adequately studied due to the not easy access of seafarer's medical data[3,13,15]. Previous studies have reported that non-officers have a higher risk for diseases and injuries compared to officers[3,15–18], but most of these studies considered only occupational groups.

The exposure to the work-related risk of officers and non-officers working in different ship areas such as deck, engine, and galley is not similar because they attend different duties in different working hours[19]. For instance, workers in the engine room are exposed to work-

related risks such as noise, vibration, and heat or pollutants during their working hours[19,20]. In contrast, people working in the deck, as well as in the galley, are potentially exposed to different work-related risks[19]. Because of the different areas of activity and associated burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study on the incidence rates of injury and disease by rank and worksite of seafarers would provide information for prevention strategies such as resource allocation, prioritizing training areas, improving the medicine chests on board, and access to telemedicine consultation to reduce injury and disease at the workplace.

The present study aimed to analyze the incidence rates of reported occupational diseases and injuries among seafarers by worksite and rank groups. This work provides factual information on the rate of diseases and injuries between the worksite group as well as the rank. The results obtained can be used to prioritize occupational health risks and guide the development of preventative measures onboard container ships.

2. METHODS

2.1. Study design, data source, and collection procedure

We employed a retrospective study design and received data from the Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M. is the Italian Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than 100,000 seafarers onboard ships [21]. CMA CGM S.A. is a French container transport and shipping company. It is a leading shipping group globally, using 200 shipping routes between 420 ports in 150 different countries. In this particular study, the data source we used was reported diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome. CMA CGM S.A. shipping company made a contractual agreement with C.I.R.M. in January 2016 to identify new approaches to provide high-quality telemedical assistance for seafarers. In view of this agreement, data provided for medical assistance on the company's board ships are more detailed and, therefore, can be used for a basic epidemiological analysis.

Work-related diseases are diseases predominantly due to physical, chemical, and biological factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M. database according to the World Health Organization (WHO) International Classification of Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden, unexpected, and unwanted forceful event due to an external cause's onboard ships. In the

C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version (chapter XIX, S00-S99, and T00-T98).

The classification of both diseases and occupational injuries was made according to the prompt diagnosis and recorded medical datasets in the C.I.R.M. database. The injury and disease rates measured were based on the contacts from onboard container ships to the Telemedical Maritime Assistance Service (TMAS) in Rome. Any contact for medical requests from ships to the C.I.R.M. with injuries or cases of illness with important patient data, including age, sex, job, rank, the nationality of the patient, ship flag, ship name, date of medical event that occurred, anatomic location of the injury, diagnosis, treatment provided, the patient follow-up schedule and other relevant information are registered in the database. Hence, we got access to occupational injuries and diseases with seafarers' rank and job from the TMAS database for this particular study.

An estimated total number of at-risk seafarer population was calculated by multiplying the number of vessels during the study period by the average number of crew members per vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an average size of 20 crew members per ship[3]. The CMA CGM shipping company handles only container ships, with an average of 25 crew members per ship. Regarding rank distribution per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck workers, thirteen engine workers and two galleys (catering) workers are in service per vessel. The average number of the crew size, their rank as well as worksite distribution per large vessel based on the knowledge of industry norm were calculated.

The number of CMA CGM container ships contracted over four years, from January 2016 to December 31, 2019, was 539. An estimated number of the total at-risk seafarer population for worksite and rank was determined by multiplying the total number of vessels over four years by occupation and rank distribution per ship. The total number of seafarers at risk was adjusted proportionally to the number of seafarers in the dataset for whom information on occupation and rank was available.

2.2. Statistical analysis

Descriptive statistics such as mean and standard deviation (SD) of age, frequency, and percentage of injuries by anatomic location and types of diseases were done to evaluate the distribution of reported occupational injuries and diseases in seafarers with injuries and diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley). The worksite was also categorized into three groups, including

the deck, engine, and galley. Then, worksite and rank specific incidence rates (IR) were calculated by dividing the number of cases by the total at-risk seafarer population for each worksite and rank over four years. Incidence rate ratio (IRR) and 95% confidence interval (CI) were calculated to compare the injuries and diseases rates by seafarer's rank and worksite. The outcome of rates was expressed as per 1,000 seafarer-years. Seafarer-year is defined as the number of crew members per ship multiplied by the number of vessels each year. The Chi-square or Fisher's exact test was used to determine distributional differences in rank and worksite groups. A two-tailed P <0.05 was considered statistically significant. The STATA software version 15 was used for data analysis.

2.3. Patient and public involvement

Patients and public were not involved in the study

3. RESULTS

Overall, 423 patients were assisted by the C.I.R.M. aboard container ships during the four-year study period. Of these, 338 (80%) and 85 (20%) were diseases and injuries, respectively. However, 11% (37) of the total number of patients with the disease and 8% (7) of the injured patients were unknown as to rank and worksite. The mean age (SD) of seafarers with diseases and injuries was 40.37 + 12.52 years and 38.39 + 12.88 years, respectively. Non-officers were more likely than officers to be injured (IRR = 1.75) and to have reported the disease (IRR = 1.45). Deck workers are almost 2 times more likely than engine workers to be injured (p <0.004) (Table 1).

Table 1. Number of cases, seafarer-years, incidence rates, and incidence rate ratios of injury and disease by rank and worksite of seafarers from 2016 to 2019.

Variable	Injury (n = 78)	Seafarer-years	Injury incidence rate (95% CI)	IRR* (95% CI)	P-value
Total	78	12,365	6.31 (4.98 – 7.86)	N/A	
Rank					
Officer	19	4,451	4.27 (2.57 – 6.66)	1	
Non-officer	59	7,914	7.45 (5.68 – 9.61)	**1.75** (1.02 – 3.10)	0.029
Worksite					
Deck	43	4,946	8.69 (6.29 – 11.69)	**1.99** (1.21 – 3.34)	0.004
Engine	28	6,430	4.35 (2.89 – 6.29)	1	
Galley	7	989	7.07 (2.85 – 14.53)		
	Disease(n=301)	Seafarer-years	Disease incidence rate (95% CI)	IRR* (95% CI)	
Total	301	12,000	25.00 (22.36 – 28.04)	N/A	

Rank					
Officer	84	4320	19.44 (15.54 – 24.02)	1	
Non-officer	217	7680	28.25 (24.66 – 32.21)	**1.45** (1.12 – 1.89)	0.003
Worksite					
Deck	171	4,800	35.63 (30.56 – 41.26)	**2.12**(1.65 – 2.72)	0.001
Engine	105	6,240	16.83 (13.78 – 20.33)	1	
Galley	25	960	26.00 (16.92 – 38.20)		

Abbreviation: N/A , not applicable, *IRR only reported the result with a significant comparison at p <0.05 for non-officer vs. officer, deck vs. engine, deck vs. galley, and engine vs. galley.

The most frequent causes of illnesses onboard ships were gastrointestinal disorders (n = 71, 21%) followed by musculoskeletal (n = 52, 15%) and cardiovascular diseases (n = 51, 15%) (Figure 1). In general, out of the 85 injuries, 29% were wrist and hand injuries, 21% were knee/lower leg injuries, 13% were head/eye injuries, 12% were lower back/lumbar spine injuries, 8% were thorax/neck injuries (Figure 2).

Rank-specific incidence rates of occupational injuries and diseases

Gastrointestinal diseases were the most common disorders for officers (IR = 3.07 per 1000 seafarer-years) and non-officers (IR = 6.51 per 1000 seafarer-years), as presented in Table 2. The most common injuries for non-officer was wrist/hand (1.93 per 1000 seafarer-years) and knee/lower leg (1.84 per 1000 seafarer-years). The incidence rate ratio (IRR) for non-officers' versus officers was determined and reported in Table 2. As a result, non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. Concerning injuries, non-officers were more likely than officers to be injured in the knee or lower leg (IRR = 4.21) (Table 2).

Table 2. Incidence Rate of diseases and occupational injuries by the seafarer rank from 2016 to 2019 (n = 379)

Medical events	Officer			Non-officer			IRR[a]	95% CI	P-value
	No.	Rate	95% CI	No.	Rate	95% CI			
Disease types									
Gastrointestinal	13	3.07	1.64 - 5.24	49	6.51	4.82 - 8.59	2.12	1.13 – 4.26	0.011*
Musculoskeletal	10	2.14	1.03 - 3.94	40	4.82	3.45 - 6.56	2.25	1.11 – 5.05	0.016*
Cardiovascular	10	2.69	1.29 - 4.95	29	4.39	2.95 - 6.31	1.63	0.77 – 3.75	0.179
Non-specific	12	2.86	1.47 - 4.99	20	2.68	1.64 - 4.14	0.94	0.44 – 2.10	0.849
Respiratory	11	2.59	1.29 - 4.63	17	2.25	1.31 - 3.60	0.87	0.38 – 2.05	0.711
Dermatological	4	0.88	0.24 - 2.25	26	3.22	2.10 - 4.71	3.66	1.27 – 14.42	0.007*
Genitourinary	10	2.06	0.99 - 3.78	11	1.27	0.64 - 2.28	0.62	0.24 – 1.63	0.280
Eye/Adnexa	6	1.31	0.48 - 2.86	10	1.23	0.59 - 2.27	0.94	0.31 – 3.14	0.887
Infectious and parasitic	5	1.26	0.40 - 2.94	4	0.57	0.15 - 1.45	0.45	0.09 – 2.09	0.250
Ear/Mastoid	2	0.41	0.05 - 1.49	4	0.46	0.13 - 1.19	1.13	0.16 – 12.44	0.927
Neurological[b]	—	—	—	4	0.46	0.13 - 1.19	—	—	N/A
Mental/behavioral	1	0.21	0.005 - 1.14	3	0.35	0.07 - 1.02	1.69	0.14 – 88.59	0.713
Injury Location									
Wrist/Hand	8	1.72	0.74 - 3.38	16	1.93	1.11 - 3.14	1.13	0.45 – 3.03	0.801
Knee/lower leg	2	0.44	0.05 - 1.57	15	1.84	1.03 – 3.03	4.20	1.01 – 38.01	0.032*
Head/Eye	3	0.76	0.16 - 2.21	6	0.85	0.31 - 1.85	1.13	0.24 – 6.95	0.898
Lower back/lumbar spine	3	0.77	0.16 - 2.25	5	0.73	0.24 - 1.69	0.94	0.18 – 6.07	0.911
Thorax/neck	1	0.21	0.005 - 1.14	6	0.69	0.25 - 1.51	3.37	0.41 - 155	0.261
Skin burns	1	0.21	0.005 - 1.14	5	0.58	0.19 - 1.35	2.81	0.31 - 133	0.369
Upper arm/shoulder	1	0.27	0.006 - 1.53	3	0.46	0.09 - 1.35	1.69	0.14 – 88.6	0.710
Elbow/forearm[b]	—	—	—	4	0.46	0.13 - 1.18	—	—	N/A

*Significant at *P-value <0.05, [a]IRR calculated as the rate of non-officer/rate of officer, [b]Dashes indicate no case or the rate or the comparison that was not performed, Abbreviation: N/A , not applicable.*

Worksite-specific incidence rates of diseases and occupational injuries

Table 3 summarizes the rates of diseases and injuries per seafarer worksite groups. Consequently, gastrointestinal (IR = 7.01), cardiovascular (IR = 6.06) and musculoskeletal (IR = 5.40) diseases were the most common disorders for deck workers. Musculoskeletal disorders (IR =2.52) were the second most common diseases for engine workers. Wrist/hand injuries (IR = 2.89) were the most common injury for both deck and galley workers, while knee/lower leg injuries (IR = 1.06) were for engine workers (Table 3).

Table 3. Incidence rates of diseases and occupational injuries by seafarer's worksite from 2016 to 2019 (n= 379)

Medical events	Deck			Engine			Galley		
	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
Disease types									
Gastrointestinal	33	7.01	4.83 - 9.83	23	3.76	2.38 - 5.63	6	6.37	2.34 – 13.83
Musculoskeletal	28	5.40	3.59 - 7.79	17	2.52	1.47 - 4.04	5	4.82	1.56 – 11.22
Cardiovascular	25	6.06	3.93 – 8.94	10	1.86	0.89 – 3.43	4	4.85	1.32 – 12.38
Non-specific	18	3.86	2.29 – 6.09	13	2.15	1.14 – 3.66	1	1.07	0.03 – 5.96
Respiratory	18	3.82	2.26 – 6.02	9	1.46	0.67 – 2.78	1	1.06	0.03 – 5.89
Dermatological	20	3.96	2.42 – 6.11	6	0.91	0.34 – 1.98	4	3.96	1.08 – 10.09
Genitourinary	11	2.04	1.02 – 3.65	9	1.28	0.59 – 2.43	1	0.93	0.02 – 5.16
Eye/Adnexa	7	1.38	0.56 – 2.84	8	1.21	0.52 – 2.39	1	0.98	0.03 – 5.48
Infectious and parasitic[b]	5	1.13	0.37 – 2.64	4	0.69	0.19 – 1.79	—	—	—
Ear/Mastoid	1	0.19	0.004 – 1.03	4	0.57	0.16 – 1.46	1	10.93	0.02 – 5.16
Neurological	2	0.37	0.05 – 1.34	1	0.14	0.003 – 0.79	1	0.93	0.02 – 5.16
Mental/behavioral[b]	3	0.56	0.12 – 1.62	1	0.14	0.003 – 0.79	—	—	—
Injury Location									
Wrist/Hand	15	2.89	1.62 - 4.77	6	0.89	0.33 – 1.94	3	2.89	0.59 – 8.45
Knee/lower leg[b]	10	1.96	0.94 - 3.61	7	1.06	0.43 – 2.18	—	—	—
Head/Eye	6	1.36	0.49 - 2.96	2	0.35	0.04 – 1.26	1	1.13	0.03 – 6.30
Lower back/lumbar spine	4	0.93	0.25-2.37	3	0.54	0.11 – 1.56	1	1.16	0.03 – 6.44
Thorax/neck[b]	3	0.56	0.11 – 1.63	4	0.57	0.16 – 1.46	—	—	—
Skin burns	1	0.19	0.004 – 1.03	4	0.57	0.16 – 1.46	1	0.93	0.02 – 5.16
Upper arm/shoulder[b]	1	0.25	0.006 – 1.38	2	0.38	0.05 – 1.37	—	—	—
Elbow/forearm[b]	3	0.56	0.11-1.63	—	—	—	1	0.93	0.02 – 5.16

[b]*Dashes indicate no case or the rate that was not performed.*

The IRRs for deck workers versus engine workers', deck workers versus galley workers', and engine workers versus galley workers were calculated and presented in Table 4. As a result, deck workers were more likely than engine workers to have reported gastrointestinal (IRR = 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR = 2.14) disorders. Also, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25)(Table 4).

Table 4. Incidence rate ratios (IRR) and 95% confidence intervals (95% CI) of diseases and occupational injuries stratified by seafarers' worksite from 2016 to 2019 (n = 379)

Medical events	Deck vs. Engine			Deck vs. Galley			Engine vs. Galley		
	IRR	95% CI	p-value	IRR	95% CI	P-value	IRR	95% CI	P-value
Disease types									
Gastrointestinal	1.86	1.06 – 3.33	0.021*	1.09	0.45 – 3.21	0.869	0.59	0.23 – 1.77	0.263
Musculoskeletal	2.14	1.13 – 4.17	0.013*	1.12	0.43 – 3.72	0.857	0.52	0.19 – 1.81	0.224
Cardiovascular	3.26	1.51 – 7.58	0.001*	1.25	0.43 – 4.94	0.721	0.39	0.11 – 1.68	0.135
Non-specific	1.80	0.83 – 3.99	0.108	3.59	0.57 - 149	0.182	1.99	0.30 – 84.9	0.561
Respiratory	2.62	1.11 – 6.57	0.017*	3.59	0.56 – 149	0.182	1.38	0.19 – 60.7	0.846
Dermatological	4.35	1.68 – 13.18	0.001*	1.00	0.34 – 4.03	1.044	0.23	0.05 – 1.11	0.053
Genitourinary	1.59	0.59 – 4.34	0.311	2.20	0.31 - 94	0.494	1.38	0.19 – 60.68	0.846
Eye/Adnexa	1.14	0.35 – 3.59	0.803	1.40	0.18 - 63	0.837	1.23	0.17 – 55	0.933
Infectious and parasitic[b]	1.63	0.35 – 8.19	0.486	—	—	N/A	—	—	N/A
Ear/Mastoid	0.32	0.006 – 3.28	0.337	0.20	0.002 – 15.6	0.333	0.61	0.06 – 30.30	0.646
Neurological	2.60	0.14 - 153	0.485	0.40	0.02 – 23.5	0.495	0.15	0.001 – 12	0.267
Mental/behavioral[b]	3.90	0.31 - 204	0.257	—	—	N/A	—	—	N/A
Injury Location									
Wrist/Hand	3.25	1.19 – 10.23	0.012*	1.00	0.28 – 5.39	1.050	0.31	0.06 – 1.90	0.130
Knee/lower leg[b]	1.86	0.64 – 5.75	0.216	—	—	N/A	—	—	N/A
Head/Eye	3.90	0.69 – 39.50	0.089	1.20	0.15 - 55	0.949	0.31	0.02 - 18	0.398
Lower back/lumbar spine	1.73	0.29 – 11.80	0.494	0.80	0.08 – 39.7	0.794	0.46	0.04 - 24	0.524
Thorax/neck[b]	0.98	0.14 – 5.76	0.987	—	—	N/A	—	—	N/A
Skin burns	0.33	0.01 – 3.28	0.337	0.20	0.003 – 15.7	0.333	0.62	0.06 – 30.30	0.646
Upper arm/shoulder[b]	0.65	0.01 – 12.50	0.778	—	—	N/A	—	—	N/A
Elbow/forearm[b]	—	—	N/A	0.60	0.05 – 31.5	0.649	—	—	N/A

*Significant at *p-value <0.05, [b]Dashes indicate the comparison that was not performed, Abbreviation: N/A , not applicable.*

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4. DISCUSSION

This descriptive epidemiological study was mainly designed to quantify the incidence rates of reported injuries and diseases among seafarers by worksite and rank groups. We have found that the rates of overall reported diseases were four times higher than the corresponding total reported injuries rates across all worksites. A similar finding was reported from a study conducted in the USA[15], which reported 2 to 3 times total illnesses higher in the worksites than overall injuries. The overall reported disease rate was 25 per 1,000 seafarer-year during the study period. The disease rate for non-officers and officers were significantly differed [IRR: $1.45\,(95\%\,\mathrm{CI}) = 1.12 - 1.89$]. This study reported that the most common causes of illnesses on board were gastrointestinal (21%), musculoskeletal (15%), and cardiovascular disorders (15%). Similar findings were reported in a Japanese study[22], which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not consistent with the study conducted in the USA[3], which reported that dental (26%), respiratory (19%), and dermatological (14%) disorders were in the order the illnesses occurring most often among sailing seafarers.

The majority of gastrointestinal (63%) cases were gastroesophageal reflux (GERD), esophagitis, ulcers, gastritis, hernia, and appendicitis. Our work has demonstrated that non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. This study also revealed that deck workers were more likely than engine workers to have gastrointestinal (IRR = 1.86), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR = 2.14) disorders. These might be due to work-related stress because maritime officers, including the captain, have high-level responsibilities such as navigation, planning, organization of loading and unloading operations, and ship controls[19,23]. Non-officers are involved in other tasks occurring during a voyage and their work is physically more demanding and stressful than officers. In general, seafarers have high work-related stressors when compared to ashore workers[20] because their work is characterized by long working hours, often time-pressure, prolonged isolation from family, and hectic activity. Various studies have reported that work-related stress has long been considered a contributing factor in the development of musculoskeletal problems[24] and gastrointestinal disorders[25]. Similarly, as for dermatological disorders, it might result in skin exposure to risk factors in the workplace. Seafaring is a risky activity characterized by exposure to different skin risk factors such as seawater, humidity, solar radiation, and others[26,27]. Deck crews are frequently engaged in maintenance, repair,

loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk factors[28,29]. This study also reported the same rate of dermatological disorders for the deck (IR = 3.96) and galley (IR = 3.96) workers. However, this could be due to the small number of cases among galley workers, and even the estimated non-cases of galley workers are not comparable in number to deck workers' non-cases. Consequently, 95% of the confidence interval was wider for the case rate among the galley workers. The IRR results in the comparison made between the workers on deck and in the galley were also not statistically significant (p = 1.044) on this matter. Further studies are needed to measure the effect of differences in the workplace of deck and galley workers on dermatological disease rates.

Angina pectoris (39% of all CVD diagnoses) was the most frequently reported cardiovascular disorders in this study. As for cardiovascular disorders, it could be related to lifestyle, especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight and obese, respectively[30]. This finding suggests that in seafarer's CVD risk factors are higher compared to ashore workers. We found that cardiovascular (IR = 6.06) disorders were the second most common diseases for deck workers and deck workers were also more likely than engine worker to have reported cardiovascular diseases (IRR = 3.26). This might be due to work-related stress because deck workers have high work-related stress due to sleep interruption, high job demands, night shift work, and intense activity than engine workers. A study reported that work related stress was a risk factor for cardiovascular diseases[31]. Long working hours are contributing factors to work-related stress, and it is logical to expect an association between long hours and cardiovascular disorders[32,33]. Studies have also shown that night shift work had adverse effects on health and risk factors for the development of chronic diseases such as cardiovascular diseases[19,34,35]. The relationship between stress and coronary heart disease are considered to be linked to multiple and protracted increases in heart rate and blood pressure resulting from neuroendocrine activation[36–39]. Other studies have reported that work-related stress can increase the cardiovascular risk of workers [40–42]. On the other hand, cardiovascular diseases and metabolic disorders are stress-related diseases[43].

The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period. The injury rate for non-officers and officers were significantly differed [IRR: $1.75\ (95\%\ \mathrm{CI}) = 1.75 - 3.10$]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and lower leg (21%). Our results agree with the study conducted in the Danish-flagged merchant fleet[18], which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover,

this study revealed that non-officers were more likely than officers to be injured (IRR = 1.75). This finding was in agreement with the previous studies[17,3,44]. Non-officer work is characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating machinery such as cranes and drilling towers, and steering the ship at sea[20,23]. The non-officer work is also physically challenging[19,20,23] and must be carried out regardless of weather conditions. This could explain why non-officers have a higher rate of injuries than officers.

The present study has shown that the deck workers had higher rates of overall reported injuries (IR = 8.69) compared to the engine (IR = 4.35) workers. These results are consistent with those of the study conducted in the USA[15]. We found also the injury rate for deck workers and engine workers were significantly differed [IRR: 1.99 (95% CI) =1.21 – 3.34]. Similarly, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25), as shown in Table 4. A study conducted in Danish Fleet seafarers[44] reported that deck workers had a relatively low risk for injuries compared to machine (engine) workers. The difference could be due to methodological differences. The study on seafarers in the Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to determine incidence rates and incidence rate ratios in the Danish fleet, were not consistent with our study. Deck workers, particularly deck ratings, perform physical works such as mooring and unmooring the ship, loading, and unloading cargo[23]. Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than engine workers because they are engaged in the surveillance system with frequent irregular operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs and maintenance work in the deck area[19,20,23]. Hence, night shift work, long working hours, short average sleep time, and physical stress are important factors contributing to the high rates of injuries/accidents at sea[10,19,45,46].

Strengths and limitations

This study measured the incidence rates of reported injury and disease to TMAS for container ships. Most of the previous studies on diseases and injuries among seafarers were focused on the number of cases. As far as we know, this study is the first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarers onboard container ships. Limitations of this study are: 1). We used an estimated average number of seafarers per ship in the analysis, although we took into account different assumptions, including the number of vessels, ships active at sea, number of crew members per ship, and the length of stay of seafarers on board for the accuracy of the estimate. Consequently, the incidence rate may be underestimated or overestimated. 2). Data from

patients with injuries and cases of disease contained descriptions such as age and gender, but we had no descriptions of these data on the total at-risk seafarer population. Hence, we have not determined the rates and incidence rate ratios of the diseases and injuries by seafarers' age and sex. 3). Patient data on both injury and diagnosis were compiled according to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not on mechanisms of injury or potential physical hazards related to injured cases. As a result, we have not stratified injuries by mechanisms of injury or occupational hazards to highlight priority areas and recommend preventative measures. 4). We did not have descriptions of data types such as socio-demographic variables and another exposure status of the total seafarer population at risk. In this respect, we have not determined the risk factors for injury and disease to propose further prevention strategies. Furthermore, this study is a retrospective study and limited to the variables available in the dataset. Finally, our study is limited to container ships and does not represent other types of ships at sea. Hence, the results do not reflect seafarers working on other types of ships.

CONCLUSION

The results of this study were based on the medical events (diseases and occupational injuries) of seafarers while working on board container ships. Non-officers had significantly higher rates of reported gastrointestinal, musculoskeletal, and dermatological disorders comaperd to officers. Also, non-officers were more likely than officers to be injured in the knee and lower leg. Deck workers had significantly higher rates for dermatological, cardiovascular, musculoskeletal, respiratory, and gastrointestinal disorders when compared to engine workers. Deck workers were more likely than engine workers to be injured in the wrist and hand. In general, the total reported injury and disease rates for non-officers were significantly higher compared to officers.The same is true for deck workers compared to engine workers. Hence, this study suggests the need for rank and work site-specific prevention strategies to reduce injury and disease rates at the workplace. Future studies should consider the risk factors for injury and disease among seafarers in order to propose further preventive measures.

Contributors

GGS.: conceived and designed the study, performed analysis, methodology, interpreted the data and results, and drafted the initial manuscript. MD: extracted data and assisted with the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted

the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and approved the study. All authors approved the final version of the manuscript.

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Conflict of interests

The authors declared that they have no conflict of interest.

Ethical approval

The study has been reviewed and approved by the Scientific/Ethics Committee of the C.I.R.M. Foundation.

Patient consent for publication: Not required

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Legends of the figures

Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n = 338)

Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n = 85)

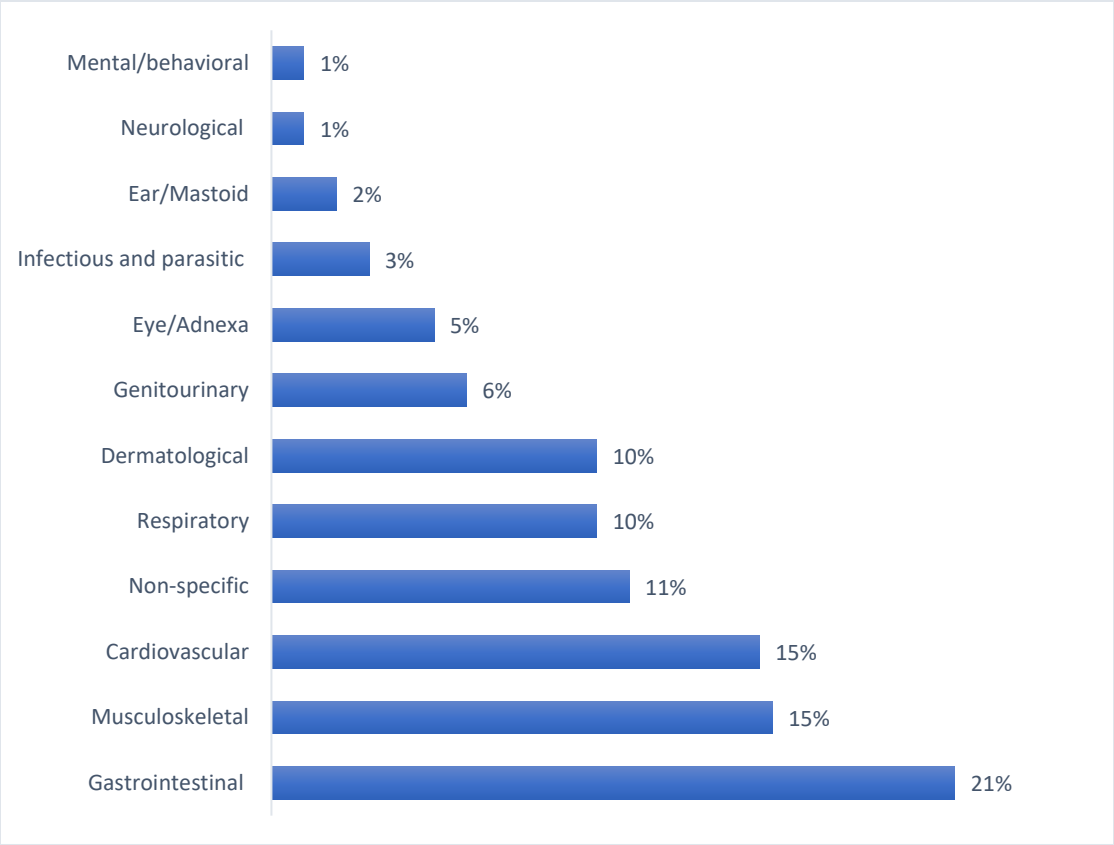

Figure 1

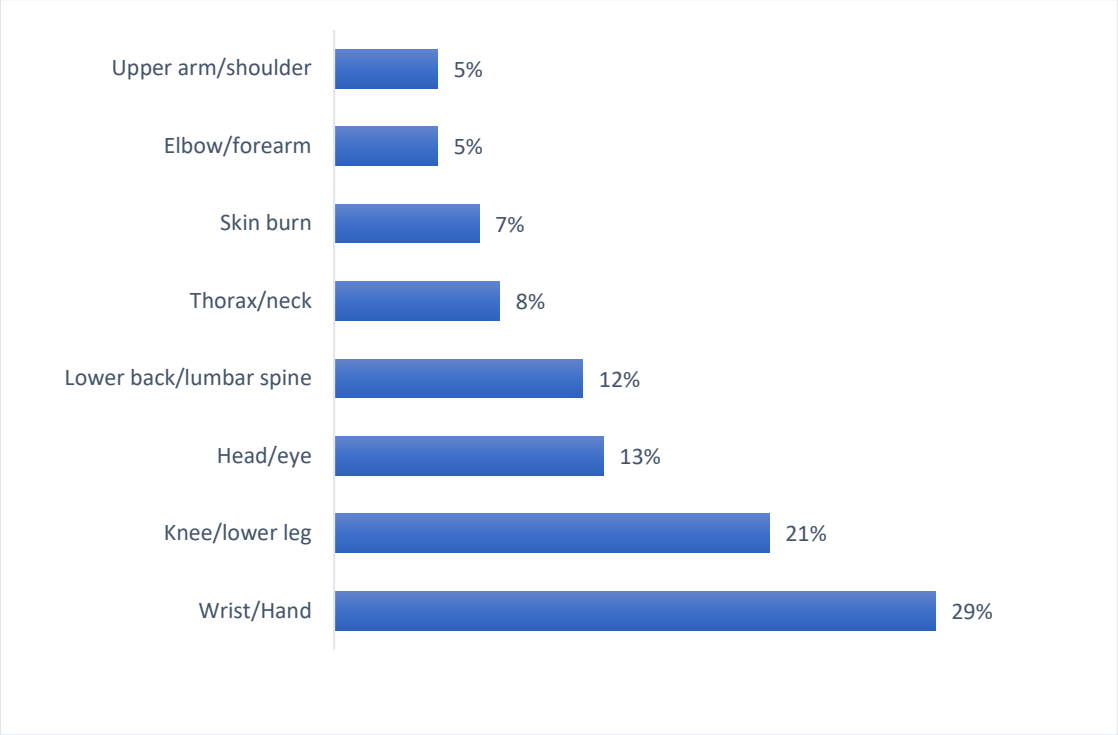

Figure 2

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6 &7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5 &6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6 & 7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5&6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7, 8, 9,11 & 13
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	14, 15 & 16
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16 & 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Incidence of occupational injuries and diseases among seafarers: a descriptive epidemiological study based on contacts from onboard ships to the Italian Telemedical Maritime Assistance service in Rome, Italy

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Abstract

Objectives: Workers at sea have high mortality, injuries, and illnesses and work in a hazardous environment compared to ashore workers. The present study was designed to measure the incidence of occupational injuries and diseases among seafarers and quantify the contribution of differences in rank and job onboard on seafarers' diseases and injuries rates.

Design: Descriptive epidemiological study

Setting and participants: This study's data were based on contacts (n = 423) for medical requests from CMA CGM container ships to the Italian Telemedical Maritime Assistance Service (TMAS) in Rome from 2016 to 2019, supplemented by data on the estimated total at-risk seafarer population on container ships (n =13,475) over the study period.

Outcome measures: Distribution of injuries by anatomic location and types of diseases across seafarers' ranks and worksites. We determined the incidence rate and incidence rate ratio (IRR) with a 95% confidence interval (CI).

Results: The total disease rate was 25 per 1,000 seafarer-years, and the overall injury rate was 6.31 per 1,000 seafarer-years over the four years study period. Non-officers were more likely than officers to have reported gastrointestinal [IRR: 2.12 (95% CI) = 1.13 – 4.26], dermatological [IRR: 3.66 (95% CI) = 1.27 – 14.42] and musculoskeletal [IRR: 2.25 (95% CI) = 1.11–5.05] disorders onboard container ships. Deck workers were more likely than engine workers to be injured in the wrist and hand (IRR:3.25 (95% CI) = 1.19 – 10.23).

Conclusions: Rates of reported injury and disease were significantly higher among non-officers than officers; thus, this study suggests the need for rank-specific preventative measures. Future studies should consider risk factors for injury and disease among seafarers in order to propose further preventive measures.

Keywords: Epidemiology, Injury, Disease, Seafarer, Rank, Occupation

Strengths and limitations of this study

- The first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarer's onboard container ships.
- This study measured the incidence rates and Incidence rate ratios of injury and disease by rank and worksite of seafarers based on contacts from onboard container ships to TMAS.
- The estimated at-risk seafarer population was used in the analysis due to the lack of information on the actual at-risk seafarer population.

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively[1]. It is estimated that nearly 65,000 deep-sea merchant ships operate worldwide, carrying more than 1.6 million sailing seafarers[1,2].

In general, work onboard ships are broadly grouped by working areas, including the deck, engine, and galley[3]. Shipping is one of the most widespread transportation systems, and more than 88% of the world's trade utilizes it[4,5]. Workers at sea have high mortality, injuries, and diseases rate compared to ashore workers[5]. Sailing seafarers have a one in eleven chance of being injured on duty on board [6], and sometimes physical injuries can be acute and a primary cause of disability. Different studies have reported higher mortality and morbidity rates onboard merchant ships when compared to the land occupation. For instance, a study conducted on the British merchant fleet reported that between 2003 to 2012, the fatal accident rate in shipping was 21 times higher than that in the general British workforce, 4.7 times higher than that in the construction industry, and 13 times higher than in manufacturing[7]. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore[8]. Moreover, seafarers working on board of British merchant ships had 23.9 times higher risk of mortality due to accidents at work than all workers in Great Britain[9]. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km[10].

Identifying the potential area of incidents and assessing the probability of the occurrence of occupational medical events may assure the availability of treatment and the development of prevention strategies to reduce the rate of diseases and/or injuries among seafarers and to improve health outcomes[11–13]. Unfortunately, due to the scarcity of evidence-based information on the incidence of occupational diseases and injuries onboard ships, preventive measures in the maritime environment received less attention than other working activities [14]. On the other hand, determinants of onboard merchant ship illnesses, injuries, disability, and fatalities, remain not adequately studied due to the not easy access of seafarer's medical data[3,13,15]. Previous studies have reported that non-officers have a higher risk for diseases and injuries compared to officers[3,15–18], but most of these studies considered only occupational groups.

The exposure to the work-related risk of officers and non-officers working in different ship areas such as deck, engine, and galley is not similar because they attend different duties in different working hours[19]. For instance, workers in the engine room are exposed to work-

related risks such as noise, vibration, and heat or pollutants during their working hours[19,20]. In contrast, people working in the deck, as well as in the galley, are potentially exposed to different work-related risks[19]. Because of the different areas of activity and associated burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study on the incidence rates of injury and disease by rank and worksite of seafarers would provide information for prevention strategies such as resource allocation, prioritizing training areas, improving the medicine chests on board, and access to telemedicine consultation to reduce injury and disease at the workplace.

The present study aimed to analyze the incidence rates of reported occupational diseases and injuries among seafarers by worksite and rank groups. This work provides factual information on the rate of diseases and injuries between the worksite group as well as the rank. The results obtained can be used to prioritize occupational health risks and guide the development of preventative measures onboard container ships.

2. METHODS

2.1. Study design, data source, and collection procedure

We employed a descriptive epidemiological study and received data from the Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M. is the Italian Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than 100,000 seafarers onboard ships [21]. CMA CGM S.A. is a French container transport and shipping company. It is a leading shipping group globally, using 200 shipping routes between 420 ports in 150 different countries. In this particular study, the data source we used was reported diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome. CMA CGM S.A. shipping company made a contractual agreement with C.I.R.M. in January 2016 to identify new approaches to provide high-quality telemedical assistance for seafarers. In view of this agreement, data provided for medical assistance on the company's board ships are more detailed and, therefore, can be used for a basic epidemiological analysis.

Work-related diseases are diseases predominantly due to physical, chemical, and biological factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M. database according to the World Health Organization (WHO) International Classification of Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden, unexpected, and unwanted forceful event due to an external cause's onboard ships. In the

C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version (chapter XIX, S00-S99, and T00-T98).

The classification of both diseases and occupational injuries was made according to the prompt diagnosis and recorded medical datasets in the C.I.R.M. database. The injury and disease rates measured were based on the contacts from onboard container ships to the Italian Telemedical Maritime Assistance Service (TMAS) in Rome. Any contact for medical requests from ships to the C.I.R.M. with injuries or cases of illness with important patient data, including age, sex, job, rank, the nationality of the patient, ship flag, ship name, date of medical event that occurred, anatomic location of the injury, diagnosis, treatment provided, the patient follow-up schedule and other relevant information are registered in the database. Hence, we got access to occupational injuries and diseases with seafarers' rank and job from the TMAS database for this particular study.

An estimated total number of at-risk seafarer population was calculated by multiplying the number of vessels during the study period by the average number of crew members per vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an average size of 20 crew members per ship[3]. The CMA CGM shipping company handles only container ships, with an average of 25 crew members per ship. Regarding rank distribution per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck workers, thirteen engine workers and two galleys (catering) workers are in service per vessel. The average number of the crew size, their rank as well as worksite distribution per large vessel based on the knowledge of industry norm were calculated.

The number of CMA CGM container ships contracted over four years, from January 2016 to December 31, 2019, was 539. In other words, 539 vessels represented the total number of active ships onboard in four years (January 2016 to December 31, 2019), and due to this, we determined the cumulative incidence rates. An estimated number of the total at-risk seafarer population for worksite and rank was determined by multiplying the total number of vessels over four years by occupation and rank distribution per ship. The total number of seafarers at risk was adjusted proportionally to the number of seafarers in the dataset for whom information on occupation and rank was available.

2.2. Statistical analysis

Descriptive statistics such as mean and standard deviation (SD) of age, frequency, and percentage of injuries by anatomic location and types of diseases were done to evaluate the distribution of reported occupational injuries and diseases in seafarers with injuries and

diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley). The worksite was also categorized into three groups, including the deck, engine, and galley. Then, worksite and rank specific incidence rates (IR) were calculated by dividing the number of cases by the total at-risk seafarer population for each worksite and rank over four years. Incidence rate ratio (IRR) and 95% confidence interval (CI) were calculated to compare the injuries and diseases rates by seafarer's rank and worksite. The outcome of rates was expressed as per 1,000 seafarer-years. Seafarer-year is defined as the number of crew members per ship multiplied by the number of vessels each year. The Chi-square or Fisher's exact test was used to determine distributional differences in rank and worksite groups. A two-tailed P <0.05 was considered statistically significant. The STATA software version 15 was used for data analysis.

2.3. Patient and public involvement

Patients and public were not involved in the study.

3. RESULTS

Overall, 423 patients were assisted by the C.I.R.M. aboard container ships during the four-year study period. Of these, 338 (80%) and 85 (20%) were diseases and injuries, respectively. However, 11% (37) of the total number of patients with the disease and 8% (7) of the injured patients were unknown as to rank and worksite. The mean age (SD) of seafarers with diseases and injuries was 40.37 + 12.52 years and 38.39 + 12.88 years, respectively. Non-officers were more likely than officers to be injured (IRR = 1.75) and to have reported the disease (IRR = 1.45). Deck workers are almost 2 times more likely than engine workers to be injured (p <0.004) (Table 1).

Table 1. Number of cases, seafarer-years, incidence rates, and incidence rate ratios of injury and disease by rank and worksite of seafarers from 2016 to 2019.

Variable	Injury (n = 78)	Seafarer-years	Injury incidence rate (95% CI)	IRR* (95% CI)	P-value
Total	78	12,365	6.31 (4.98 – 7.86)	N/A	
Rank					
Officer	19	4,451	4.27 (2.57 – 6.66)	1	
Non-officer	59	7,914	7.45 (5.68 – 9.61)	**1.75** (1.02 – 3.10)	0.029
Worksite					
Deck	43	4,946	8.69 (6.29 – 11.69)	**1.99** (1.21 – 3.34)	0.004
Engine	28	6,430	4.35 (2.89 – 6.29)	1	
Galley	7	989	7.07 (2.85 – 14.53)		

	Disease(n=301)	Seafarer-years	Disease incidence rate (95% CI)	IRR* (95% CI)	
Total	301	12,000	25.00 (22.36 – 28.04)	N/A	
Rank					
Officer	84	4320	19.44 (15.54 – 24.02)	1	
Non-officer	217	7680	28.25 (24.66 – 32.21)	**1.45** (1.12 – 1.89)	0.003
Worksite					
Deck	171	4,800	35.63 (30.56 – 41.26)	**2.12**(1.65 – 2.72)	0.001
Engine	105	6,240	16.83 (13.78 – 20.33)	1	
Galley	25	960	26.00 (16.92 – 38.20)		

Abbreviation: N/A , not applicable, *IRR only reported the result with a significant comparison at p <0.05 for non-officer vs. officer, deck vs. engine, deck vs. galley, and engine vs. galley.

The most frequent causes of illnesses onboard ships were gastrointestinal disorders (n = 71, 21%) followed by musculoskeletal (n = 52, 15%) and cardiovascular diseases (n = 51, 15%) (Figure 1). In general, out of the 85 injuries, 29% were wrist and hand injuries, 21% were knee/lower leg injuries, 13% were head/eye injuries, 12% were lower back/lumbar spine injuries, 8% were thorax/neck injuries (Figure 2).

Rank-specific incidence rates of occupational injuries and diseases

Gastrointestinal diseases were the most common disorders for officers (IR = 3.07 per 1000 seafarer-years) and non-officers (IR = 6.51 per 1000 seafarer-years), as presented in Table 2. The most common injuries for non-officer was wrist/hand (1.93 per 1000 seafarer-years) and knee/lower leg (1.84 per 1000 seafarer-years). The incidence rate ratio (IRR) for non-officers' versus officers was determined and reported in Table 2. As a result, non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. Concerning injuries, non-officers were more likely than officers to be injured in the knee or lower leg (IRR = 4.21) (Table 2).

Table 2. Incidence Rate of diseases and occupational injuries by the seafarer rank from 2016 to 2019 (n = 379)

Medical events	Officer			Non-officer			IRR[a]	95% CI	P-value
	No.	Rate	95% CI	No.	Rate	95% CI			
Disease types									
Gastrointestinal	13	3.07	1.64 - 5.24	49	6.51	4.82 - 8.59	2.12	1.13 – 4.26	0.011*
Musculoskeletal	10	2.14	1.03 - 3.94	40	4.82	3.45 - 6.56	2.25	1.11 – 5.05	0.016*
Cardiovascular	10	2.69	1.29 - 4.95	29	4.39	2.95 - 6.31	1.63	0.77 – 3.75	0.179
Non-specific	12	2.86	1.47 - 4.99	20	2.68	1.64 - 4.14	0.94	0.44 – 2.10	0.849
Respiratory	11	2.59	1.29 - 4.63	17	2.25	1.31 - 3.60	0.87	0.38 – 2.05	0.711
Dermatological	4	0.88	0.24 - 2.25	26	3.22	2.10 - 4.71	3.66	1.27 – 14.42	0.007*
Genitourinary	10	2.06	0.99 - 3.78	11	1.27	0.64 - 2.28	0.62	0.24 – 1.63	0.280
Eye/Adnexa	6	1.31	0.48 - 2.86	10	1.23	0.59 - 2.27	0.94	0.31 – 3.14	0.887
Infectious and parasitic	5	1.26	0.40 - 2.94	4	0.57	0.15 - 1.45	0.45	0.09 – 2.09	0.250
Ear/Mastoid	2	0.41	0.05 - 1.49	4	0.46	0.13 - 1.19	1.13	0.16 – 12.44	0.927
Neurological[b]	—	—	—	4	0.46	0.13 - 1.19	—	—	N/A
Mental/behavioral	1	0.21	0.005 - 1.14	3	0.35	0.07 - 1.02	1.69	0.14 – 88.59	0.713
Injury Location									
Wrist/Hand	8	1.72	0.74 - 3.38	16	1.93	1.11 - 3.14	1.13	0.45 – 3.03	0.801
Knee/lower leg	2	0.44	0.05 - 1.57	15	1.84	1.03 – 3.03	4.20	1.01 – 38.01	0.032*
Head/Eye	3	0.76	0.16 - 2.21	6	0.85	0.31 - 1.85	1.13	0.24 – 6.95	0.898
Lower back/lumbar spine	3	0.77	0.16 - 2.25	5	0.73	0.24 - 1.69	0.94	0.18 – 6.07	0.911
Thorax/neck	1	0.21	0.005 - 1.14	6	0.69	0.25 - 1.51	3.37	0.41 - 155	0.261
Skin burns	1	0.21	0.005 - 1.14	5	0.58	0.19 - 1.35	2.81	0.31 - 133	0.369
Upper arm/shoulder	1	0.27	0.006 - 1.53	3	0.46	0.09 - 1.35	1.69	0.14 – 88.6	0.710
Elbow/forearm[b]	—	—	—	4	0.46	0.13 - 1.18	—	—	N/A

*Significant at *P-value <0.05, [a]IRR calculated as the rate of non-officer/rate of officer, [b]Dashes indicate no case or the rate or the comparison that was not performed, Abbreviation: N/A , not applicable.*

Worksite-specific incidence rates of diseases and occupational injuries

Table 3 summarizes the rates of diseases and injuries per seafarer worksite groups. Consequently, gastrointestinal (IR = 7.01), cardiovascular (IR = 6.06) and musculoskeletal (IR = 5.40) diseases were the most common disorders for deck workers. Musculoskeletal disorders (IR =2.52) were the second most common diseases for engine workers. Wrist/hand injuries (IR = 2.89) were the most common injury for both deck and galley workers, while knee/lower leg injuries (IR = 1.06) were for engine workers (Table 3).

Table 3. Incidence rates of diseases and occupational injuries by seafarer's worksite from 2016 to 2019 (n= 379)

Medical events	Deck			Engine			Galley		
	No.	Rate	95% CI	No.	Rate	95% CI	No.	Rate	95% CI
Disease types									
Gastrointestinal	33	7.01	4.83 - 9.83	23	3.76	2.38 - 5.63	6	6.37	2.34 – 13.83
Musculoskeletal	28	5.40	3.59 - 7.79	17	2.52	1.47 - 4.04	5	4.82	1.56 – 11.22
Cardiovascular	25	6.06	3.93 – 8.94	10	1.86	0.89 – 3.43	4	4.85	1.32 – 12.38
Non-specific	18	3.86	2.29 – 6.09	13	2.15	1.14 – 3.66	1	1.07	0.03 – 5.96
Respiratory	18	3.82	2.26 – 6.02	9	1.46	0.67 – 2.78	1	1.06	0.03 – 5.89
Dermatological	20	3.96	2.42 – 6.11	6	0.91	0.34 – 1.98	4	3.96	1.08 – 10.09
Genitourinary	11	2.04	1.02 – 3.65	9	1.28	0.59 – 2.43	1	0.93	0.02 – 5.16
Eye/Adnexa	7	1.38	0.56 – 2.84	8	1.21	0.52 – 2.39	1	0.98	0.03 – 5.48
Infectious and parasitic[b]	5	1.13	0.37 – 2.64	4	0.69	0.19 – 1.79	—	—	—
Ear/Mastoid	1	0.19	0.004 – 1.03	4	0.57	0.16 – 1.46	1	10.93	0.02 – 5.16
Neurological	2	0.37	0.05 – 1.34	1	0.14	0.003 – 0.79	1	0.93	0.02 – 5.16
Mental/behavioral[b]	3	0.56	0.12 – 1.62	1	0.14	0.003 – 0.79	—	—	—
Injury Location									
Wrist/Hand	15	2.89	1.62 - 4.77	6	0.89	0.33 – 1.94	3	2.89	0.59 – 8.45
Knee/lower leg[b]	10	1.96	0.94 - 3.61	7	1.06	0.43 – 2.18	—	—	—
Head/Eye	6	1.36	0.49 - 2.96	2	0.35	0.04 – 1.26	1	1.13	0.03 – 6.30
Lower back/lumbar spine	4	0.93	0.25-2.37	3	0.54	0.11 – 1.56	1	1.16	0.03 – 6.44
Thorax/neck[b]	3	0.56	0.11 – 1.63	4	0.57	0.16 – 1.46	—	—	—
Skin burns	1	0.19	0.004 – 1.03	4	0.57	0.16 – 1.46	1	0.93	0.02 – 5.16
Upper arm/shoulder[b]	1	0.25	0.006 – 1.38	2	0.38	0.05 – 1.37	—	—	—
Elbow/forearm[b]	3	0.56	0.11-1.63	—	—	—	1	0.93	0.02 – 5.16

[b]*Dashes indicate no case or the rate that was not performed.*

The IRRs for deck workers versus engine workers', deck workers versus galley workers', and engine workers versus galley workers were calculated and presented in Table 4. As a result, deck workers were more likely than engine workers to have reported gastrointestinal (IRR = 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR = 2.14) disorders. Also, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25)(Table 4).

Table 4. Incidence rate ratios (IRR) and 95% confidence intervals (95% CI) of diseases and occupational injuries stratified by seafarers' worksite from 2016 to 2019 (n = 379)

Medical events	Deck vs. Engine			Deck vs. Galley			Engine vs. Galley		
	IRR	95% CI	p-value	IRR	95% CI	P-value	IRR	95% CI	P-value
Disease types									
Gastrointestinal	1.86	1.06 – 3.33	0.021*	1.09	0.45 – 3.21	0.869	0.59	0.23 – 1.77	0.263
Musculoskeletal	2.14	1.13 – 4.17	0.013*	1.12	0.43 – 3.72	0.857	0.52	0.19 – 1.81	0.224
Cardiovascular	3.26	1.51 – 7.58	0.001*	1.25	0.43 – 4.94	0.721	0.39	0.11 – 1.68	0.135
Non-specific	1.80	0.83 – 3.99	0.108	3.59	0.57 - 149	0.182	1.99	0.30 – 84.9	0.561
Respiratory	2.62	1.11 – 6.57	0.017*	3.59	0.56 – 149	0.182	1.38	0.19 – 60.7	0.846
Dermatological	4.35	1.68 – 13.18	0.001*	1.00	0.34 – 4.03	1.044	0.23	0.05 – 1.11	0.053
Genitourinary	1.59	0.59 – 4.34	0.311	2.20	0.31 - 94	0.494	1.38	0.19 – 60.68	0.846
Eye/Adnexa	1.14	0.35 – 3.59	0.803	1.40	0.18 - 63	0.837	1.23	0.17 – 55	0.933
Infectious and parasitic[b]	1.63	0.35 – 8.19	0.486	—	—	N/A	—	—	N/A
Ear/Mastoid	0.32	0.006 – 3.28	0.337	0.20	0.002 – 15.6	0.333	0.61	0.06 – 30.30	0.646
Neurological	2.60	0.14 - 153	0.485	0.40	0.02 – 23.5	0.495	0.15	0.001 – 12	0.267
Mental/behavioral[b]	3.90	0.31 - 204	0.257	—	—	N/A	—	—	N/A
Injury Location									
Wrist/Hand	3.25	1.19 – 10.23	0.012*	1.00	0.28 – 5.39	1.050	0.31	0.06 – 1.90	0.130
Knee/lower leg[b]	1.86	0.64 – 5.75	0.216	—	—	N/A	—	—	N/A
Head/Eye	3.90	0.69 – 39.50	0.089	1.20	0.15 - 55	0.949	0.31	0.02 - 18	0.398
Lower back/lumbar spine	1.73	0.29 – 11.80	0.494	0.80	0.08 – 39.7	0.794	0.46	0.04 - 24	0.524
Thorax/neck[b]	0.98	0.14 – 5.76	0.987	—	—	N/A	—	—	N/A
Skin burns	0.33	0.01 – 3.28	0.337	0.20	0.003 – 15.7	0.333	0.62	0.06 – 30.30	0.646
Upper arm/shoulder[b]	0.65	0.01 – 12.50	0.778	—	—	N/A	—	—	N/A
Elbow/forearm[b]	—	—	N/A	0.60	0.05 – 31.5	0.649	—	—	N/A

*Significant at *p-value <0.05, [b]Dashes indicate the comparison that was not performed, Abbreviation: N/A , not applicable.*

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4. DISCUSSION

This descriptive epidemiological study was mainly designed to quantify the incidence rates of reported injuries and diseases among seafarers by worksite and rank groups. We have found that the rates of overall reported diseases were four times higher than the corresponding total reported injuries rates across all worksites. A similar finding was reported from a study conducted in the USA[15], which reported 2 to 3 times total illnesses higher in the worksites than overall injuries. The overall reported disease rate was 25 per 1,000 seafarer-year during the study period. The disease rate for non-officers and officers were significantly differed [IRR: $1.45\,(95\%\,\mathrm{CI}) = 1.12 - 1.89$]. This study reported that the most common causes of illnesses on board were gastrointestinal (21%), musculoskeletal (15%), and cardiovascular disorders (15%). Similar findings were reported in a Japanese study[22], which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not consistent with the study conducted in the USA[3], which reported that dental (26%), respiratory (19%), and dermatological (14%) disorders were in the order the illnesses occurring most often among sailing seafarers.

The majority of gastrointestinal (63%) cases were gastroesophageal reflux (GERD), esophagitis, ulcers, gastritis, hernia, and appendicitis. Our work has demonstrated that non-officers were more likely than officers to have gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66) disorders. This study also revealed that deck workers were more likely than engine workers to have gastrointestinal (IRR = 1.86), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR = 2.14) disorders. These might be due to work-related stress because maritime officers, including the captain, have high-level responsibilities such as navigation, planning, organization of loading and unloading operations, and ship controls[19,23]. Non-officers are involved in other tasks occurring during a voyage and their work is physically more demanding and stressful than officers. In general, seafarers have high work-related stressors when compared to ashore workers[20] because their work is characterized by long working hours, often time-pressure, prolonged isolation from family, and hectic activity. Various studies have reported that work-related stress has long been considered a contributing factor in the development of musculoskeletal problems[24] and gastrointestinal disorders[25]. Similarly, as for dermatological disorders, it might result in skin exposure to risk factors in the workplace. Seafaring is a risky activity characterized by exposure to different skin risk factors such as seawater, humidity, solar radiation, and others[26,27]. Deck crews are frequently engaged in maintenance, repair,

loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk factors[28,29]. This study also reported the same rate of dermatological disorders for the deck (IR = 3.96) and galley (IR = 3.96) workers. However, this could be due to the small number of cases among galley workers, and even the estimated non-cases of galley workers are not comparable in number to deck workers' non-cases. Consequently, 95% of the confidence interval was wider for the case rate among the galley workers. The IRR results in the comparison made between the workers on deck and in the galley were also not statistically significant (p = 1.044) on this matter. Further studies are needed to measure the effect of differences in the workplace of deck and galley workers on dermatological disease rates.

Angina pectoris (39% of all CVD diagnoses) was the most frequently reported cardiovascular disorders in this study. As for cardiovascular disorders, it could be related to lifestyle, especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight and obese, respectively[30]. This finding suggests that in seafarer's CVD risk factors are higher compared to ashore workers. We found that cardiovascular (IR = 6.06) disorders were the second most common diseases for deck workers and deck workers were also more likely than engine worker to have reported cardiovascular diseases (IRR = 3.26). This might be due to work-related stress because deck workers have high work-related stress due to sleep interruption, high job demands, night shift work, and intense activity than engine workers. A study reported that work related stress was a risk factor for cardiovascular diseases[31]. Long working hours are contributing factors to work-related stress, and it is logical to expect an association between long hours and cardiovascular disorders[32,33]. Studies have also shown that night shift work had adverse effects on health and risk factors for the development of chronic diseases such as cardiovascular diseases[19,34,35]. The relationship between stress and coronary heart disease are considered to be linked to multiple and protracted increases in heart rate and blood pressure resulting from neuroendocrine activation[36–39]. Other studies have reported that work-related stress can increase the cardiovascular risk of workers [40–42]. On the other hand, cardiovascular diseases and metabolic disorders are stress-related diseases[43].

The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period. The injury rate for non-officers and officers were significantly differed [IRR: $1.75\ (95\%\ \mathrm{CI}) = 1.75 - 3.10$]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and lower leg (21%). Our results agree with the study conducted in the Danish-flagged merchant fleet[18], which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover,

this study revealed that non-officers were more likely than officers to be injured (IRR = 1.75). This finding was in agreement with the previous studies[17,3,44]. Non-officer work is characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating machinery such as cranes and drilling towers, and steering the ship at sea[20,23]. The non-officer work is also physically challenging[19,20,23] and must be carried out regardless of weather conditions. This could explain why non-officers have a higher rate of injuries than officers.

The present study has shown that the deck workers had higher rates of overall reported injuries (IR = 8.69) compared to the engine (IR = 4.35) workers. These results are consistent with those of the study conducted in the USA[15]. We also found the injury rate for deck workers and engine workers were significantly differed [IRR: 1.99 (95% CI) =1.21 – 3.34]. Similarly, deck workers were more likely than engine workers to be injured in the wrist and hand (IRR = 3.25), as shown in Table 4. A study conducted in Danish Fleet seafarers[44] reported that deck workers had a relatively low risk for injuries compared to machine (engine) workers. The difference could be due to methodological differences. The study on seafarers in the Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to determine incidence rates and incidence rate ratios in the Danish fleet, were not consistent with our study. Deck workers, particularly deck ratings, perform physical works such as mooring and unmooring the ship, loading, and unloading cargo[23]. Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than engine workers because they are engaged in the surveillance system with frequent irregular operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs and maintenance work in the deck area[19,20,23]. Hence, night shift work, long working hours, short average sleep time, and physical stress are important factors contributing to the high rates of injuries/accidents at sea[10,19,45,46].

Strengths and limitations

This study measured the incidence rates of reported injury and disease to TMAS for container ships. Most of the previous studies on diseases and injuries among seafarers were focused on the number of cases. As far as we know, this study is the first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarers onboard container ships. Limitations of this study are: 1). We used an estimated average number of seafarers per ship in the analysis, although we took into account different assumptions, including the number of vessels, ships active at sea, number of crew members per ship, and the length of stay of seafarers on board for the accuracy of the estimate. Consequently, the incidence rate may be underestimated or overestimated. 2). Data from

patients with injuries and cases of disease contained descriptions such as age and gender, but we had no descriptions of these data on the total at-risk seafarer population. Hence, we have not determined the rates and incidence rate ratios of the diseases and injuries by seafarers' age and sex. 3). Patient data on both injury and diagnosis were compiled according to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not on mechanisms of injury or potential physical hazards related to injured cases. As a result, we have not stratified injuries by mechanisms of injury or occupational hazards to highlight priority areas and recommend preventative measures. 4). We did not have descriptions of data types such as socio-demographic variables and another exposure status of the total seafarer population at risk. In this respect, we have not determined the risk factors for injury and disease to propose further prevention strategies. Furthermore, this study is a retrospective study and limited to the variables available in the dataset. Finally, our study is limited to container ships and does not represent other types of ships at sea. Hence, the results do not reflect seafarers working on other types of ships.

CONCLUSION

The results of this study were based on the medical events (diseases and occupational injuries) of seafarers while working on board container ships. Non-officers had significantly higher rates of reported gastrointestinal, musculoskeletal, and dermatological disorders compared to officers. Also, non-officers were more likely than officers to be injured in the knee and lower leg. Deck workers had significantly higher rates for dermatological, cardiovascular, musculoskeletal, respiratory, and gastrointestinal disorders when compared to engine workers. Deck workers were more likely than engine workers to be injured in the wrist and hand. In general, the total reported injury and disease rates for non-officers were significantly higher compared to officers. The same is true for deck workers compared to engine workers. Hence, this study suggests the need for rank and work site-specific prevention strategies to reduce injury and disease rates at the workplace. Future studies should consider the risk factors for injury and disease among seafarers in order to propose further preventive measures.

Contributors

GGS.: conceived and designed the study, performed analysis, methodology, interpreted the data and results, and drafted the initial manuscript. MD: extracted data and assisted with the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted

the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and approved the study. All authors approved the final version of the manuscript.

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Conflict of interests

The authors declared that they have no conflict of interest.

Ethical approval

The study has been reviewed and approved by the Scientific/Ethics Committee of the C.I.R.M. Foundation.

Patient consent for publication: Not required.

Data availability statement: No additional data available

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Legends of the figures

Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n = 338)

Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n = 85)

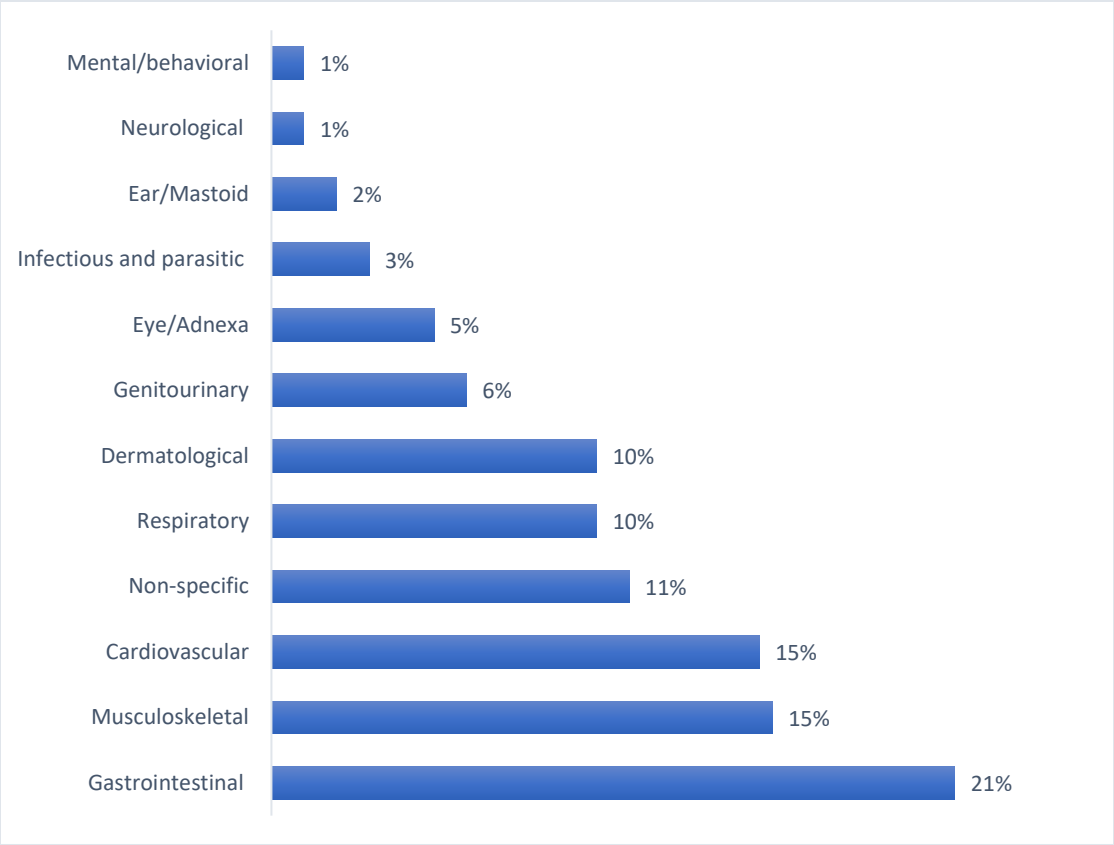

Figure 1

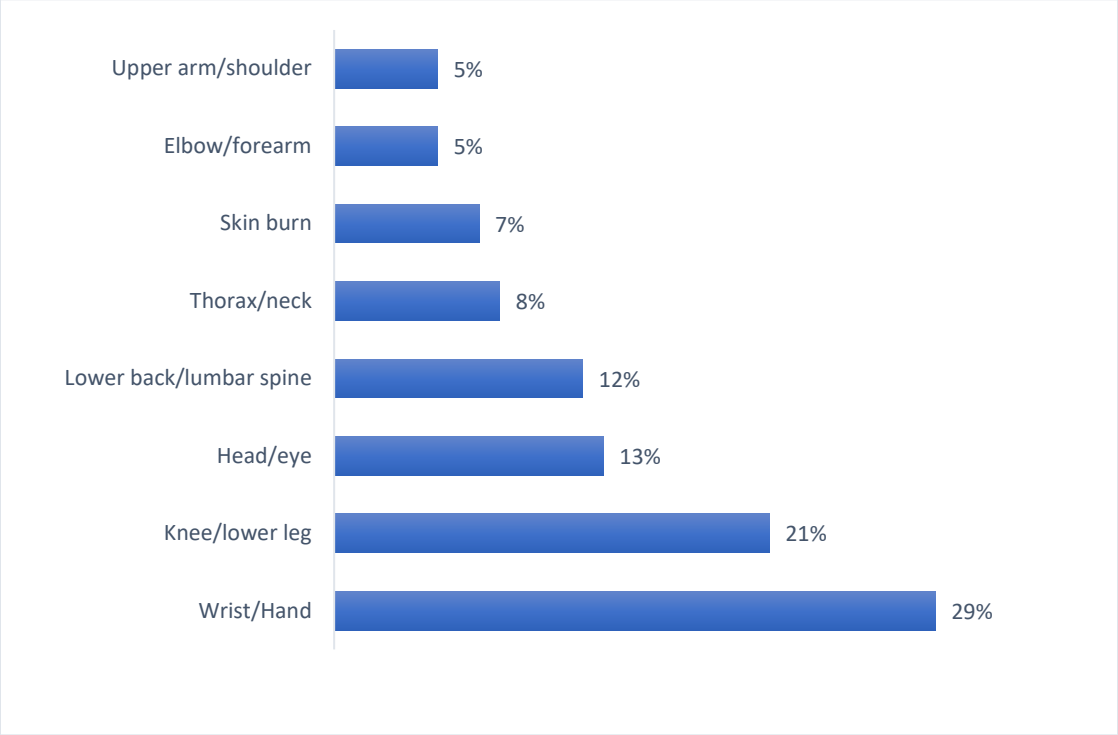

Figure 2

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6 &7
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5 &6
Bias	9	Describe any efforts to address potential sources of bias	6
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6 & 7
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5&6
		(b) Indicate number of participants with missing data for each variable of interest	6
		(c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	6
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7, 8, 9,11 & 13
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	14, 15 & 16
Limitations			
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16 & 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.