

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044633
Article Type:	Original research
Date Submitted by the Author:	08-Sep-2020
Complete List of Authors:	Sagaro, Getu Gamo; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences; University of Camerino di Canio, Marzio; Research Department, International Radio Medical Centre (CIRM), Battineni, Gopi ; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences Samad, Marc; CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille Amenta, Francesco; Universita degli Studi di Camerino Scuola di Scienze del Farmaco e dei Prodotti della Salute, Telemedicine and Telepharmacy Centre
Keywords:	Epidemiology < TROPICAL MEDICINE, EPIDEMIOLOGY, Epidemiology < INFECTIOUS DISEASES, OCCUPATIONAL & INDUSTRIAL MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 **Epidemiology of occupational injuries and diseases among seafarers:**
4
5 **Implications for prevention**
6

7 *Getu Gamo Sagaro*^{1*}, *Marzio Di Canio*², *Gopi Battenini*¹, *Marc Abdul Samad*³ and *Francesco*
8 *Amenta*^{1,2}
9

10
11 ¹Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences,
12 University of Camerino, 62032 Camerino, Italy
13

14
15 ²Research Department, Internazionale Radio Medical Center (C.I.R.M), 00144 Rome, Italy
16

17 ³CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille, France
18
19
20
21
22

23 **Corresponding Author:**
24

25 Getu Gamo Sagaro
26 Telemedicine and Telepharmacy Center
27 School of Medicinal and Health Products Sciences,
28 University of Camerino
29 62032 Camerino MC, Italy
30 E-mail: getugamo.sagaro@unicam.it
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

For peer review only

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively¹. 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 galley³. 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 workers⁵. Sailing seafarers have one in eleven chances of being injured on duty on board⁶, 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 manufacturing⁷. Mortality in Danish seafarers onboard ships was found to be 11.5 times higher compared to Danish male ashore workers between 1986 to 1993⁸. Moreover, seafarers working on board of British merchant ships had 23.9 times higher risk of death compared to all workers in Great Britain⁹. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km¹⁰.

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 outcomes¹¹⁻¹³. 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 activities¹⁴. 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 hours¹⁹. For instance, workers in the engine room are exposed to work-

1
2
3 related risks such as noise, vibration, and heat or pollutants during their working hours^{19,20}.
4 In contrast, people working in the deck, as well as in the galley, are potentially exposed to
5 different work-related risks¹⁹. Because of the different areas of activity and associated burden,
6 the likelihood of illnesses and the occurrence of injuries can differ, and evidence-based
7 information can be used for preventive measures.
8
9

10
11 The aim of present study was to analyze the incidence of occupational diseases and injuries
12 among seafarers by worksite and rank groups. This work provides factual information on the
13 risk of illnesses and injuries between the worksite group as well as the rank. The results
14 obtained can be used to prioritize occupational health risks and guide the development of
15 preventative measures onboard merchant ships.
16
17
18

19 20 **2. METHODS**

21 22 **2.1. Study design, data source, and collection procedure**

23
24 We employed a retrospective study design and received data from the Centro Internazionale
25 Radio Medico (International Radio Medical Centre, C.I.R.M) database. C.I.R.M is the Italian
26 Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best
27 known TMAS worldwide. C.I.R.M operates since 1935 and has assisted more than 100,000
28 seafarers onboard ships²¹. For this particular study, we have used CMA CGM group vessels'
29 occupational illnesses, and injuries claim records. CMA CGM shipping company has made an
30 agreement with C.I.R.M in January 2016 to identify new approaches to provide high-quality
31 telemedical assistance for seafarers. In view of this agreement, data provided for medical
32 assistance on board ships of the company are more detailed and, therefore, can be used for
33 a basic epidemiological analysis.
34
35
36
37
38
39
40

41 Work-related diseases are illnesses predominantly due to physical, chemical, and biological
42 factors associated with merchant seafaring occupations, and they are recorded in the CIRM
43 database according to the World Health Organization (WHO) International Classification of
44 Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden,
45 unexpected, and unwanted forceful event due to an external cause onboard merchant
46 seafaring occupation. In the C.I.R.M database, injuries also are recorded according to the
47 WHO ICD 10th revised version (chapter XIX, S00-S99, and T00-T98).
48
49
50
51

52
53 The classification of both illnesses and occupational injuries was made according to the prompt
54 diagnosis and recorded medical datasets in the C.I.R.M database. The attributes included in
55
56
57
58
59
60

1
2
3 the database were age, gender, rank, working site, type of vessel, means of contacts, days,
4 months, and years of diagnosis. Disease and injury diagnosis affected body parts, and ICD
5 10 for both diseases and injuries were included in the dataset. For the analysis of the incidence
6 of illnesses and injuries, the rank and worksite groups were the parameters considered.
7
8
9

10 An estimated total number of at-risk seafarer population was calculated by multiplying the
11 number of vessels during the study period by the average number of crew members per
12 vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an
13 average size of 20-25 crew members per ship³. The CMA CGM shipping company handles only
14 container ships, with an average of 25 crew members per ship. Regarding rank distribution
15 per ship, nine officers and sixteen non-officers (ratings) serve onboard. In respect of worksite,
16 ten deck workers, thirteen engine workers and two galleys (catering) workers are in service
17 per vessel. The average number of the crew size, their rank as well as worksite distribution
18 per large vessel based on the knowledge of industry norm were calculated.
19
20
21
22
23

24 The number of CMA CGM container ships contracted over four years from January 2016 to
25 December 31, 2019, was 539. An estimated number of the total at-risk seafarer population
26 for worksite and rank was determined by multiplying the total number of vessels over four
27 years by occupation and rank distribution per ship. The total number of seafarers at risk was
28 adjusted proportionally to the number of seafarers in the dataset for whom information on
29 occupation and rank was available. Then, worksite and rank specific incidence rates were
30 calculated by dividing the number of cases by the total at-risk seafarer population for each
31 occupation and rank over four years. Moreover, the incidence rate ratio (IRR) and 95%
32 confidence interval were performed to quantify the rate difference between rank groups as
33 well as worksite groups. The outcome of rates was expressed as per 1,000 seafarer-years.
34
35
36
37
38
39
40

41 **2.2. Statistical analysis**

42
43 Descriptive analysis of seafarer's demographic variables, including age, rank, and worksite,
44 was done to evaluate the distribution of occupational injuries and diseases. Rank was stratified
45 by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley).
46 The worksite was also categorized into three groups, including the deck, engine, and galley.
47 The Chi-square or Fisher's exact test was used to determine distributional differences in rank
48 and worksite groups. The Z- test and independent-sample t-tests to compare mean and
49 proportions, respectively, were used. A two-tailed $P < 0.05$ was considered statistically
50 significant. The STATA software version 15 was used for data analysis.
51
52
53
54
55
56
57
58
59
60

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 USA¹⁵, 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

1
2
3 and obese, respectively²². This finding suggests that in seafarer's CVD risk factors are higher
4 compared to ashore workers. On the other hand, cardiovascular diseases and metabolic
5 disorders are stress-related diseases²³. Seafarers have high work-related stressors when
6 compared to ashore workers²⁰ because their work is characterized by long working hours,
7 often time-pressure, prolonged isolation from family, and hectic activity. Various studies have
8 reported that work-related stress has long been considered a contributing factor in the
9 development of coronary heart disease²⁴, musculoskeletal problems²⁵, and gastrointestinal
10 disorders²⁶. Similar findings were reported in a Japanese study²⁷, which has shown that
11 gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular diseases (11.6%)
12 were the diseases more often occurring onboard ships. Our findings are not consistent with
13 the study conducted in the USA³, which reported that dental (26%), respiratory (19%), and
14 dermatological (14%) disorders were in the order the pathologies occurring most often among
15 sailing seafarers. Our work has also demonstrated that non-officers had 1.45 times higher
16 risk for total diseases, and 2.12, 2.25, and 3.66 times significantly higher risk for
17 gastrointestinal, musculoskeletal, and dermatological disorders, respectively than officers.
18
19
20
21
22
23
24
25

26
27 Deck workers had 2.11 times higher risk for total diseases compared to engine workers. In
28 particular, deck workers had 4.33, 3.25, 2.60, 2.14, and 1.87 times higher risk for
29 dermatological, cardiovascular, respiratory, musculoskeletal, and gastrointestinal disorders,
30 respectively, when compared to engine workers. Cardiovascular pathologies might be due to
31 work-related stress because deck workers have high work-related stress due to sleep
32 interruption, high job demands, night shift work, and intense activity than engine workers.
33 Long working hours are contributing factors to work-related stress, and it is logical to expect
34 an association between long hours and cardiovascular disorders²⁸. The relationship between
35 stress and coronary heart disease are considered to be linked to multiple and protracted
36 increases in heart rate and blood pressure resulting from neuroendocrine activation^{29,30}. Other
37 studies have reported that work-related stress can increase the cardiovascular risk of workers
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000

1
2
3 experience and of attention in performing the required tasks may be a cause of injuries.
4 Nearly 30% of injuries occurred in the wrist and hand, followed by knee and lower leg
5 (21.20%). Our results agree with the study conducted in the Danish-flagged merchant fleet¹⁸,
6 which reported that 36% and 18% of upper and lower limb injuries, respectively. Moreover,
7 this study revealed that non-officers had 1.75 times higher risk for injuries compared to
8 officers. These findings are agree with previous studies reporting that non-officer have nearly
9 1.60 times higher risk for injuries compared to officers^{17,3,38}. Maritime officers, including the
10 captain, have high-level responsibilities such as navigation, planning, organization of loading
11 and unloading operations, and ship controls^{19,39}. Non-officers are involved in other tasks
12 occurring during a voyage such as mooring, cleaning the ship, repairing broken lines and
13 ropes, operating machinery like cranes and derricks, and also perform steering of the ship at
14 sea^{20,39}. The non-officer work is also physically challenging^{19,20,39} and must be carried out
15 regardless of weather conditions. This could explain why non-officers have a higher risk of
16 injuries than officers.
17
18
19
20
21
22
23

24
25 The present study has shown that the deck workers had higher rates of overall injuries
26 compared to engine and galley workers. These results are consistent with those of the study
27 conducted in the USA¹⁵. Similarly, deck workers had a significantly higher risk for wrist and
28 hand injuries compared to engine workers. A study conducted in Danish Fleet seafarers³⁸
29 reported that deck workers had a relatively low risk for injuries compared to machine (engine)
30 workers. Deck workers, particularly deck ratings, perform physical works such as mooring
31 and unmooring the ship, loading, and unloading cargo³⁹.
32
33
34
35

36
37 Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than
38 engine workers because they are engaged in the surveillance system with frequent irregular
39 operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge,
40 or carrying out repairs and maintenance work in the deck area^{19,20,39}. Hence, night shift work,
41 long working hours, short average sleep time, and physical stress are important factors
42 contributing to the high rates of injuries/accidents at sea^{10,19,28,40}.
43
44
45

46 **Strengths and limitations**

47
48
49 Most of the previous studies on pathologies and accidents among seafarers were focused on
50 the number of cases occurring without a specific epidemiological analysis of the phenomenon.
51 This study measured the incidence of disease and injury for rank and occupation groups by
52 estimating the seafarer population of underlying at risk in the rank and workplace categories.
53 Also, our study demonstrated the incidence rate ratio (IRR) to compare the risk between rank
54
55
56
57
58
59
60

1
2
3 and occupation groups. Limits of this work are in the use of the estimated at-risk seafarer
4 population in the analysis due to the lack of information on actual at-risk seafarer population.
5 As a result, the incidence rate may be underestimated or overestimated. Moreover, we have
6 not measured injury and disease incidence rates by age, gender, work experience, and
7 nationality due to a lack of these information on the total at-risk seafarer population.
8
9
10

11 **CONCLUSION**

12
13
14 In general, non-officers and deck workers had a higher risk for diseases and injuries over the
15 four years of the study period. Non-officers had a significantly higher risk for gastrointestinal,
16 musculoskeletal, and dermatological disorders and knee and lower leg injuries. Deck officers
17 had a significantly higher risk for dermatological, cardiovascular, musculoskeletal, respiratory
18 and gastrointestinal disorders, and wrist and hand injuries. Gastrointestinal, musculoskeletal,
19 and cardiovascular disorders were the most frequent health problems onboard ships.
20
21
22

23
24 In terms of prevention, improvement in occupational safety, and the use of protective
25 equipment and training on work safety procedures could minimize the risk of injuries. A
26 comprehensive risk assessment, including the identification of hazards, evaluation of the
27 frequency of different injuries and diseases, and more efforts in specific training programs
28 will help in reducing the occurrence of occupational injuries onboard ships. The availability of
29 telemedicine devices⁴¹, and of systems for quick diagnosis of transmittable diseases in isolated
30 places such as POCRAMÉ⁴² will provide a relevant contribution to health protection of
31 seafarers. Regular health checks for non-communicable diseases, lifestyle changes such as a
32 healthy diet and regular exercise could reduce the incidence of CVD. Improved quality of food
33 provision, catering, proper hygiene, and handling of food may reduce gastrointestinal
34 disorders. More attention in training and education and following appropriate lifestyle changes
35 can contribute to improving health onboard ships are the take-home lessons that we can get
36 from epidemiology. To sum up, the availability of epidemiological data on the occurrence of
37 diseases and injuries among seafarers could increase the awareness of factors affecting health
38 on board ships moving in the direction of "prevention is better than cure," one of the main
39 goals of modern medicine.
40
41
42
43
44
45
46
47
48

49 **Contributors**

50
51 GG.S.: designed study, performed analysis, methodology, interpreted the data and results,
52 and drafted manuscript. M.D: extracted data and assisted with the preparation of manuscript.
53 G.B.: contributed to the data collection. MA.S: interpreted the data and involved in the
54
55
56
57
58
59
60

1
2
3 preparation of the manuscript. F.A: guided, edited, reviewed, and approved the study. All
4 authors approved the final manuscript.
5
6
7

8 **Funding:** This work was supported by the International Transport Workers Federation (ITF)
9 Trust, London, UK under grant number 558 to C.I.R.M. Institutional funding of the University of
10 Camerino, Italy, supported Ph.D. bursaries to G.G.S. and G.B.
11
12
13

14 **Conflict of interests**

15
16 The authors declared that they have no conflict of interest.
17
18

19 **Ethical approval**

20
21 The study has been reviewed and approved by the Scientific/Ethic Committee of the C.I.R.M
22 Foundation.
23
24

25 **Patient consent for publication:** Not required
26

27 **Data availability statement:** No additional data available
28

29 **ORCID iD**

30
31
32 Getu Gamo Sagaro <https://orcid.org/0000-0002-5983-0266>
33

34 Gopi Battenini <https://orcid.org/0000-0003-0603-2356>
35

36
37 Francesco Amenta <https://orcid.org/0000-0002-0555-1034>
38
39

40 **REFERENCES**

- 41
42
43 1. BIMCO, ICS. "Manpower Report-The global supply and demand for seafarers. *Exec*
44 *Summ.* Published online 2015:6. [http://www.ics-shipping.org/docs/default-](http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16)
45 [source/resources/safety-security-and-operations/manpower-report-2015-executive-](http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16)
46 [summary.pdf?sfvrsn=16](http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16)
47
48
49 2. Telemedicine: revolutionising healthcare for seafarers. Accessed August 10, 2019.
50 [https://www.ship-technology.com/features/featuretelemedicine-revolutionising-](https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/)
51 [healthcare-for-seafarers-5673476/](https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/)
52
53
54 3. Lefkowitz RY, Redlich CA, Mph MDS. Injury , illness , and disability risk in American
55
56
57
58
59

- 1
2
3 seafarers. *Am J Ind Med*. 2018;61:120-129. doi:10.1002/ajim.22802
4
5
6 4. IMO (International Maritime Organization). Accessed October 12, 2019.
7 <https://business.un.org/en/entities/13>
8
9
10 5. Center for Maritime Safety and Health Studies. Published online 2019. Accessed
11 October 12, 2019. https://www.cdc.gov/niosh/programs/cmshs/port_operations.html
12
13 6. Mulić, Rosanda, Pero Vidan and RB. Comparative analysis of medical assistance to
14 seafarers in the world and the republic of Croatia. *15th Int Conf Transp Sci*. Published
15 online 2012:1-8. https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf
16
17
18 7. Roberts SE, Nielsen D, Kotłowski A, Jaremin B. Fatal accidents and injuries among
19 merchant seafarers worldwide. *Occup Med (Chic Ill)*. 2014;64:259-266.
20 doi:10.1093/occmed/kqu017
21
22
23 8. Hansen HL. Surveillance of deaths on board Danish merchant ships, 1986-93:
24 Implications for prevention. *Occup Environ Med*. 1996;53:269-275.
25 doi:10.1136/oem.53.4.269
26
27
28 9. Roberts SE, Hansen HL. An analysis of the causes of mortality among seafarers in the
29 British merchant fleet (1986-1995) and recommendations for their reduction. *Occup*
30 *Med (Chic Ill)*. 2002;52:195-202. doi:10.1093/occmed/52.4.195
31
32
33 10. Berg HP. Human Factors and Safety Culture in Maritime Safety (revised). *Mar Navig*
34 *Saf Sea Transp STCW, Marit Educ Train (MET), Hum Resour Crew Manning, Marit*
35 *Policy, Logist Econ Matters*. 2013;7(3):107-115. doi:10.12716/1001.07.03.04
36
37
38 11. Carter T. Mapping the knowledge base for maritime health: 1 historical perspective.
39 *Int Marit Health*. 2011;62(4):210-216.
40
41
42 12. Carter T. Mapping the knowledge base for maritime health: 2. a framework for
43 analysis. *Int Marit Health*. 2011;62(4):217-223. Accessed October 12, 2019.
44 <http://www.ncbi.nlm.nih.gov/pubmed/22544496>
45
46
47 13. Carter T. Mapping the knowledge base for maritime health: 3 illness and injury in
48 seafarers. *Int Marit Health*. 2011;62(4):224-240.
49
50
51 14. Carter T. Mapping the knowledge base for maritime health: 4 safety and performance
52 at sea. *Int Marit Health*. 2011;62(4):236-244. Accessed October 12, 2019.
53
54
55
56
57
58
59
60

- 1
2
3 <http://www.ncbi.nlm.nih.gov/pubmed/22544498>
4
5
6 15. Lefkowitz RY, Slade MD, Redlich CA. "Injury, illness, and work restriction in merchant
7 seafarers." *Am J Ind Med*. 2015;58(6):688-696. doi:10.1002/ajim.22459
8
9
10 16. Hannerz H. Hospitalisations among seafarers on merchant ships. *Occup Env Med*.
11 2005;62:145-150. doi:10.1136/oem.2004.014779
12
13 17. Kaerlev L, Jensen A, Nielsen PS, Olsen J, Hannerz H, Tüchsen F. Hospital contacts for
14 injuries and musculoskeletal diseases among seamen and fishermen : A population-
15 based cohort study. *BioMed Cent*. 2008;9:1-9. doi:10.1186/1471-2474-9-8
16
17
18 18. Herttua K, Gerdøe S, Vork JC, Nielsen JB. Age and nationality in relation to injuries
19 at sea among officers and non- - officers : a study based on contacts from ships to
20 Telemedical Assistance Service in Denmark. *BMJ Open*. 2019;9:1-7.
21 doi:10.1136/bmjopen-2019-034502
22
23
24 19. Oldenburg M, Jensen HJ. Stress and strain among seafarers related to the
25 occupational groups. *Int J Environ Res Public Health*. 2019;16(7).
26 doi:10.3390/ijerph16071153
27
28
29 20. Oldenburg M, Jensen HJ, Latza U, Baur X. Seafaring stressors aboard merchant and
30 passenger ships. *Int J Public Health*. 2009;54(2):96-105. doi:10.1007/s00038-009-
31 7067-z
32
33
34 21. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication
35 in providing maritime medical assistance. *Int Marit Health*. 2016;67(4):187-195.
36 doi:10.5603/imh.2016.0036
37
38
39 22. Nittari G, Tomassoni D, Di Canio M, et al. Overweight among seafarers working on
40 board merchant ships. *BMC Public Health*. 2019;19(1):1-8. doi:10.1186/s12889-018-
41 6377-6
42
43
44 23. Siegrist J, Rodel A. Work stress and health risk behavior. *Scand J Work Env Heal*.
45 2006;32(6):473-481. doi:10.5271/sjweh.1052
46
47
48 24. Cooper CARYL, Marshall JUDI. Occupational sources of stress: a review of the
49 literature relating to coronary heart disease and mental ill health. *J Occup Psychol*.
50 1976;49(1):11-28.
51
52
53
54
55
56
57
58
59
60

- 1
2
3 25. Leino P. Symptoms of stress predict musculoskeletal disorders. *J Epidemiol*
4 *Community Health*. 1989;43(3):293-300. doi:10.1136/jech.43.3.293
5
6
7 26. House JS, McMichael AJ, Wells JA, Kaplan BH LL. Occupational stress and health
8 among factory workers. *J Heal Soc Behav*. 1979;20(2):139-160.
9
10
11 27. Ehara M, Muramatsu S, Sano Y, Takeda S, Hisamune S. The tendency of diseases
12 among seamen during the last fifteen years in Japan. *Ind Health*. 2006;44(1):155-
13 160. doi:10.2486/indhealth.44.155
14
15
16 28. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with
17 long working hours: A review of the current position. *Occup Environ Med*.
18 1997;54(6):367-375. doi:10.1136/oem.54.6.367
19
20
21 29. Steptoe, Andrew, George Fieldman and OE. "An experimental study of the effects of
22 control over work pace on cardiovascular responsivity." *J Psychophysiol*. 1993;7:290-
23 300.
24
25
26
27 30. Carroll, Douglas, Michael G. Harris and GC. "Haemodynamic adjustments to mental
28 stress in normotensives and subjects with mildly elevated blood pressure."
29 *Psychophysiology*. 1991;28:438-446.
30
31
32 31. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work
33 stress in the etiology of coronary heart disease - A meta-analysis. *Scand J Work*
34 *Environ Heal*. 2006;32(6):431-442. doi:10.5271/sjweh.1049
35
36
37
38 32. Jaremin B KE. Myocardial infarction (MI) at the work-site among Polish seafarers. The
39 risk and the impact of occupational factors. *Int Marit Heal*. 2003;54(1-4):26-39.
40
41
42 33. Filikowski J, Rzepiak M, Renke W, Winnicka A SD. Selected risk factors of ischemic
43 heart disease in Polish seafarers. Preliminary report. *Int Marit Heal*. 2003;54(1-4):40-
44 46.
45
46
47 34. Caruso G. "Do seafarers have sunshine." 8th International Symposium on Maritime
48 Health (ISMH) Book of abstracts. Published online 2005.
49
50
51 35. Laraqui O, Manar N, Laraqui S, et al. Prevalence of skin diseases amongst Moroccan
52 fishermen. *Int Marit Health*. 2018;69(1):22-27. doi:10.5603/IMH.2018.0004
53
54
55 36. Meyer G, Siekmann H, Feister U, Felten C HJ. Measurement of sunlight exposure in
56
57
58
59

- 1
2
3 seafaring [Ermittlung der natürlichen UV-Strahlenexposition in der Seeschiffahrt]. 50.
4 Jahrestagung der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin
5 (DGAUM). *Eur J Dermatol*. Published online 2010:434-436.
6
7
8
9 37. Oldenburg M, Kuechmeister B, Ohnemus U, Baur X, Moll I. Extrinsic skin ageing
10 symptoms in seafarers subject to high work-related exposure to UV radiation. *Eur J*
11 *Dermatology*. 2013;23(5):663-670. doi:10.1684/ejd.2013.2142
12
13
14 38. Jensen OC, Sørensen JF, Canals ML, Hu YP, Nikolic N TM. Incidence of self-reported
15 occupational injuries in seafaring — an international study. *Occup Med*.
16 2004;54(8):548-555. doi:10.1093/occmed/kqh090
17
18
19 39. STCW. International Convention on Standards of Training, Certification and
20 Watchkeeping for Seafarers. IMO. Published 1995. Accessed May 2, 2020.
21 [http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-](http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx)
22 [convention.aspx](http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx)
23
24
25
26 40. Harrington JM. Health effects of shift work and extended hours of work. *Occup*
27 *Environ Med*. 2001;58(1):68-72.
28
29
30 41. Sagaro GG, Amenta F. Past, present, and future perspectives of telemedical
31 assistance at sea: a systematic review. *Int Marit Health*. 2020;71(2):97-104.
32 doi:10.5603/IMH.2020.0018
33
34
35 42. POCRAMÉ - Rapid diagnosis of infections in isolated settings. Accessed September 8,
36 2020. <http://pocrame.com/>
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

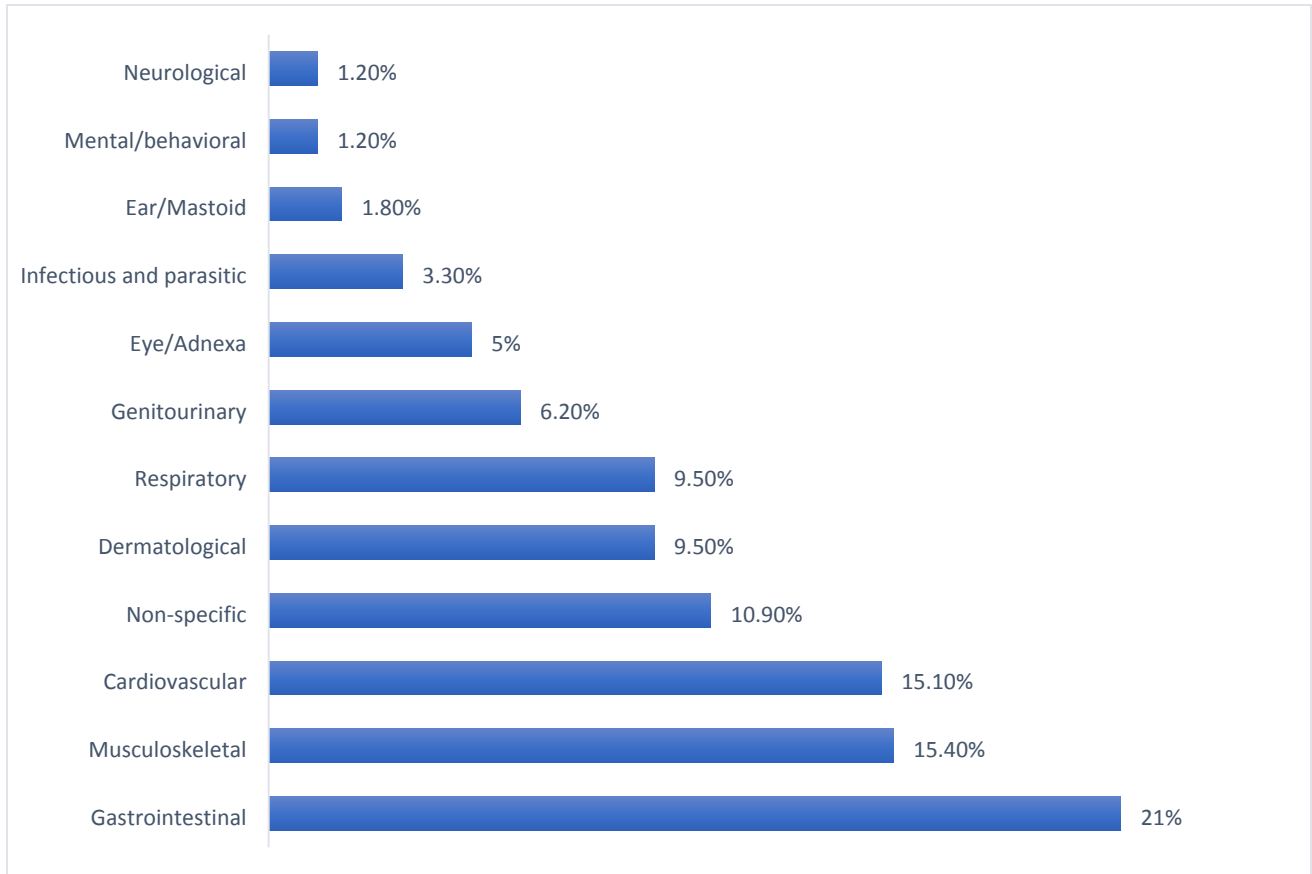


Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n = 338)

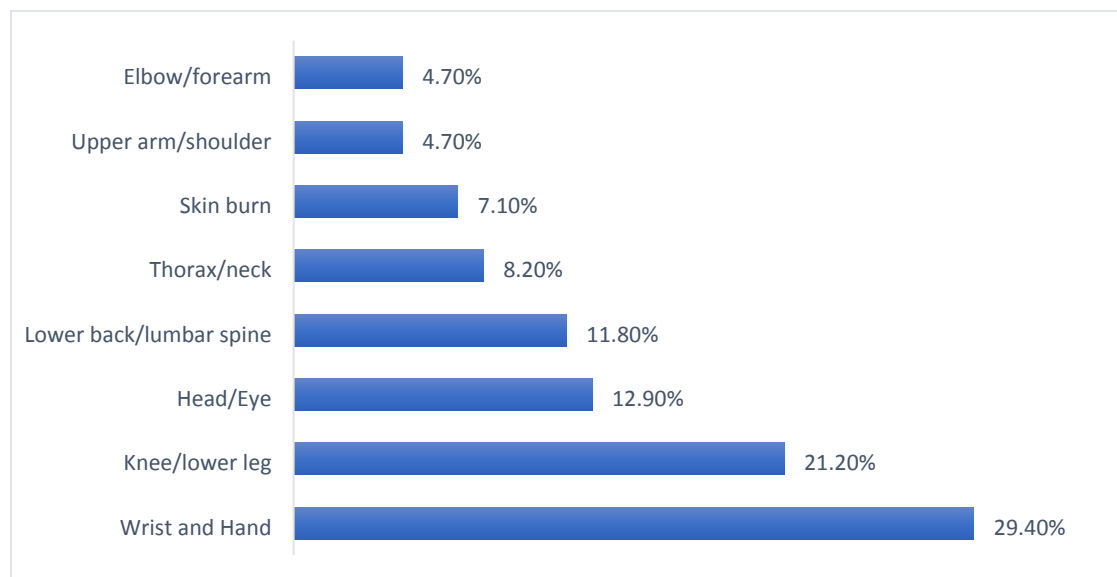


Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n = 85)

BMJ Open

Incidence of occupational injuries and diseases among seafarers

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044633.R1
Article Type:	Original research
Date Submitted by the Author:	01-Dec-2020
Complete List of Authors:	Sagaro, Getu Gamo; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences; University of Camerino Dicanio, Marzio; Research Department, International Radio Medical Centre (CIRM), Battineni, Gopi ; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences Samad, Marc; CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille Amenta, Francesco; Università degli Studi di Camerino Scuola di Scienze del Farmaco e dei Prodotti della Salute, Telemedicine and Telepharmacy Centre
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Health informatics, Cardiovascular medicine, Occupational and environmental medicine
Keywords:	Epidemiology < TROPICAL MEDICINE, EPIDEMIOLOGY, Epidemiology < INFECTIOUS DISEASES, OCCUPATIONAL & INDUSTRIAL MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Incidence of occupational injuries and diseases among seafarers

Getu Gamo Sagaro^{1}, Marzio Dicario², Gopi Battineni¹, Marc Abdul Samad³ and Francesco Amenta^{1,2}*

¹Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences, University of Camerino, 62032 Camerino, Italy

²Research Department, Internazionale Radio Medical Center (C.I.R.M), 00144 Rome, Italy

³CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille, France

Corresponding Author:

Getu Gamo Sagaro (Ph.D.)
Telemedicine and Telepharmacy Center
School of Medicinal and Health Products Sciences,
University of Camerino
62032 Camerino MC, Italy
E-mail: getugamo.sagaro@unicam.it

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, respectively¹. 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 galley³. 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 workers⁵. Sailing seafarers have a one in eleven chance of being injured on duty on board⁶, 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 manufacturing⁷. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore⁸. 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 Britain⁹. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km¹⁰.

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 outcomes¹¹⁻¹³. 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 activities¹⁴. 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 hours¹⁹. For instance, workers in the engine room are exposed to work-

1
2
3 related risks such as noise, vibration, and heat or pollutants during their working hours^{19,20}.
4 In contrast, people working in the deck, as well as in the galley, are potentially exposed to
5 different work-related risks¹⁹. Because of the different areas of activity and associated
6 burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study
7 on the incidence rates of injury and disease by rank and worksite of seafarers would provide
8 information for prevention strategies such as resource allocation, prioritizing training areas,
9 improving the medicine chests on board, and access to telemedicine consultation to reduce
10 injury and disease at the workplace.
11
12
13
14
15

16 The present study aimed to analyze the incidence rates of reported occupational diseases and
17 injuries among seafarers by worksite and rank groups. This work provides factual information
18 on the rate of illnesses and injuries between the worksite group as well as the rank. The
19 results obtained can be used to prioritize occupational health risks and guide the development
20 of preventative measures onboard container ships.
21
22
23

24 **2. METHODS**

25 **2.1. Study design, data source, and collection procedure**

26
27
28
29
30 We employed a retrospective study design and received data from the Centro Internazionale
31 Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M. is the Italian
32 Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best
33 known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than 100,000
34 seafarers onboard ships²¹. CMA CGM S.A. is a French container transport and shipping
35 company. It is a leading shipping group globally, using 200 shipping routes between 420 ports
36 in 150 different countries. In this particular study, the data source we used was reported
37 diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome. CMA CGM
38 S.A. shipping company made a contractual agreement with C.I.R.M. in January 2016 to
39 identify new approaches to provide high-quality telemedical assistance for seafarers. In view
40 of this agreement, data provided for medical assistance on the company's board ships are
41 more detailed and, therefore, can be used for a basic epidemiological analysis.
42
43
44
45
46
47
48

49 Work-related diseases are illnesses predominantly due to physical, chemical, and biological
50 factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M.
51 database according to the World Health Organization (WHO) International Classification of
52 Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden,
53 unexpected, and unwanted forceful event due to an external cause's onboard ships. In the
54
55
56
57

1
2
3 C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version
4 (chapter XIX, S00-S99, and T00-T98).
5
6

7 The classification of both illnesses and occupational injuries was made according to the prompt
8 diagnosis and recorded medical datasets in the C.I.R.M. database. The attributes included in
9 the database were age, gender, rank, working site, type of vessel, means of contacts, days,
10 months, and years of diagnosis. Disease and injury diagnosis affected body parts, and ICD
11 10 for both diseases and injuries were included in the dataset. For the analysis of the incidence
12 of illnesses and injuries, the rank and worksite groups were the parameters considered.
13
14
15

16
17 An estimated total number of at-risk seafarer population was calculated by multiplying the
18 number of vessels during the study period by the average number of crew members per
19 vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an
20 average size of 20 crew members per ship³. The CMA CGM shipping company handles only
21 container ships, with an average of 25 crew members per ship. Regarding rank distribution
22 per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck
23 workers, thirteen engine workers and two galleys (catering) workers are in service per vessel.
24 The average number of the crew size, their rank as well as worksite distribution per large
25 vessel based on the knowledge of industry norm were calculated.
26
27
28
29
30

31 The number of CMA CGM container ships contracted over four years, from January 2016 to
32 December 31, 2019, was 539. An estimated number of the total at-risk seafarer population
33 for worksite and rank was determined by multiplying the total number of vessels over four
34 years by occupation and rank distribution per ship. The total number of seafarers at risk was
35 adjusted proportionally to the number of seafarers in the dataset for whom information on
36 occupation and rank was available. Then, worksite and rank specific incidence rates were
37 calculated by dividing the number of cases by the total at-risk seafarer population for each
38 worksite and rank over four years. Incidence rate ratio (IRR) and 95% confidence interval
39 (CI) were calculated to compare the injuries and diseases rates by seafarer's rank and
40 worksite. The outcome of rates was expressed as per 1,000 seafarer-years. Seafarer-year is
41 defined as the number of crew members per ship multiplied by the number of vessels each
42 year. Descriptive analysis of seafarer's demographic variables, including age, rank, and
43 worksite, was done to evaluate the distribution of reported occupational injuries and diseases.
44 Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine
45 ratings, and galley). The worksite was also categorized into three groups, including the deck,
46 engine, and galley. The Chi-square or Fisher's exact test was used to determine distributional
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

^aIncidence rate ratio (IRR) and calculated as the rate of non-officer/rate of officer

^bDashes 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

^bDashes indicate the comparison that was not performed

The IRRs for deck workers versus engine workers¹, deck workers versus galley workers¹, 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

^bDashes 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 USA¹⁵, 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

1
2
3 of illnesses on board were gastrointestinal (21%), musculoskeletal (15.40%), and
4 cardiovascular disorders (15.10%). Similar findings were reported in a Japanese study²²,
5 which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%), and cardiovascular
6 diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not
7 consistent with the study conducted in the USA³, which reported that dental (26%),
8 respiratory (19%), and dermatological (14%) disorders were in the order the pathologies
9 occurring most often among sailing seafarers.
10
11
12
13

14 The majority of gastrointestinal (63%) cases were gastroesophageal reflux (GERD),
15 esophagitis, ulcers, gastritis, hernia, and appendicitis. This might be related to the lack of
16 fresh food in seafarers' diet and problems in food handling that may increase the risk of
17 digestive system diseases. Lower back disorders (73% of all musculoskeletal disorders) and
18 angina pectoris (39.2% of all CVD diagnoses) were the most frequently reported
19 musculoskeletal and cardiovascular disorders, respectively. As for cardiovascular disorders, it
20 could be related to work-related stress, lifestyle, especially a high-fat diet, drinking, smoking
21 and physical inactivity. A study conducted on the board of Italian flagship (2019) reported
22 that more than 40% and 10% of seafarers were overweight and obese, respectively²³. This
23 finding suggests that in seafarer's CVD risk factors are higher compared to ashore workers.
24 On the other hand, cardiovascular diseases and metabolic disorders are stress-related
25 diseases²⁴.
26
27
28
29
30
31
32

33 Our work has also demonstrated that non-officers were more likely than officers to have
34 gastrointestinal (IRR = 2.12), musculoskeletal (IRR = 2.25), and dermatological (IRR = 3.66)
35 disorders. This might be due to work-related stress because maritime officers, including the
36 captain, have high-level responsibilities such as navigation, planning, organization of loading
37 and unloading operations, and ship controls^{19,25}. Non-officers are involved in other tasks
38 occurring during a voyage and their work is physically more demanding and stressful than
39 officers. In general, seafarers have high work-related stressors when compared to ashore
40 workers²⁰ because their work is characterized²⁰ by long working hours, often time-pressure,
41 prolonged isolation from family, and hectic activity. Various studies have reported that work-
42 related stress has long been considered a contributing factor in the development of
43 musculoskeletal problems²⁶ and gastrointestinal disorders²⁷.
44
45
46
47
48
49
50

51 Gastrointestinal (IR = 7.01), cardiovascular (IR = 6.06) and musculoskeletal (IR = 5.40)
52 diseases were the most common disorders for deck workers. Similarly, deck workers were
53 more likely than engine workers to have gastrointestinal (IRR = 1.86), cardiovascular (IRR
54 = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62), and musculoskeletal (IRR =
55
56
57
58
59
60

1
2
3 2.14) disorders. Cardiovascular pathologies might be due to work-related stress because
4 deck workers have high work-related stress due to sleep interruption, high job demands,
5 night shift work, and intense activity than engine workers. A study reported that work related
6 stress was a risk factor for cardiovascular diseases²⁸. Long working hours are contributing
7 factors to work-related stress, and it is logical to expect an association between long hours
8 and cardiovascular disorders^{29,30}. Studies have also shown that night shift work had adverse
9 effects on health and risk factors for the development of chronic diseases such as
10 cardiovascular diseases^{19,31,32}. The relationship between stress and coronary heart disease
11 are considered to be linked to multiple and protracted increases in heart rate and blood
12 pressure resulting from neuroendocrine activation³³⁻³⁶. Other studies have reported that
13 work-related stress can increase the cardiovascular risk of workers³⁷⁻³⁹. As for dermatological
14 disorders, it might result in skin exposure to risk factors in the workplace. Seafaring is a risky
15 activity characterized by exposure to different skin risk factors such as seawater, humidity,
16 solar radiation, and others^{40,41}. Deck crews are frequently engaged in maintenance, repair,
17 loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk
18 factors^{42,43}.

19
20
21
22
23
24
25
26
27
28 The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period.
29 The injury rate for non-officers and officers were significantly differed [IRR: 1.75 (95% CI) =
30 1.75 – 3.10]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and
31 lower leg (21.20%). Our results agree with the study conducted in the Danish-flagged
32 merchant fleet¹⁸, which reported 36% and 18% of upper and lower limb injuries, respectively.
33 Moreover, this study revealed that non-officers were more likely than officers to be injured
34 (IRR = 1.75). This finding was in agreement with the previous studies^{17,3,44}. Non-officer work
35 is characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating
36 machinery such as cranes and drilling towers, and steering the ship at sea^{20,25}. The non-officer
37 work is also physically challenging^{19,20,25} and must be carried out regardless of weather
38 conditions. This could explain why non-officers have a higher rate of injuries than officers.

39
40
41
42
43
44
45
46 The present study has shown that the deck workers had higher rates of overall reported
47 injuries (IR = 8.69) compared to the engine (IR = 4.35) and galley (IR = 7.07) workers.
48 These results are consistent with those of the study conducted in the USA¹⁵. We found that
49 the injury rate for deck workers and engine workers were significantly differed [IRR: 1.99
50 (95% CI) =1.21 – 3.34]. Similarly, deck workers were more likely than engine workers to be
51 injured in the wrist and hand (IRR = 3.25), as shown in Table 4. A study conducted in Danish
52 Fleet seafarers⁴⁴ reported that deck workers had a relatively low risk for injuries than machine
53
54
55
56
57

(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 cargo²⁵. 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

1
2
3 limited to container ships and does not represent other types of ships at sea. Hence, the
4 results do not reflect seafarers working on other types of ships.
5
6
7

8 9 **CONCLUSION**

10
11 Non-officers had significantly higher rates of overall reported diseases, specifically
12 gastrointestinal, musculoskeletal, and dermatological disorders. Also, non-officers were more
13 likely than officers to be injured in the knee and lower leg. Deck workers had significantly
14 higher rates for dermatological, cardiovascular, musculoskeletal, respiratory, and
15 gastrointestinal disorders. Deck workers were more likely than engine workers to be injured
16 in the wrist and hand. Overall injury and disease rates for non-officers and officers significantly
17 differed. The same is true between deck workers and engine workers. Hence, this study
18 suggests the need for rank and work site-specific prevention strategies to reduce injury and
19 disease rates at the workplace. Future studies should consider the risk factors for injury and
20 disease among seafarers in order to propose further preventive measures.
21
22
23
24
25
26

27 **Contributors**

28
29 GGS.: conceived and designed the study, performed analysis, methodology, interpreted the
30 data and results, and drafted the initial manuscript. MD: extracted data and assisted with
31 the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted
32 the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and
33 approved the study. All authors approved the final version of the manuscript.
34
35
36
37
38

39 **Funding:** This work was supported by the International Transport Workers Federation (ITF)
40 Trust, London, UK, under grant number 558 to C.I.R.M. Institutional funding of the University of
41 Camerino, Italy, supported Ph.D. bursaries to GGS and GB.
42
43
44

45 **Conflict of interests**

46
47 The authors declared that they have no conflict of interest.
48
49
50
51
52
53
54
55
56
57
58
59
60

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

ORCID iD

Getu Gamo Sagaro <https://orcid.org/0000-0002-5983-0266>

Gopi Battenini <https://orcid.org/0000-0003-0603-2356>

Francesco Amenta <https://orcid.org/0000-0002-0555-1034>

REFERENCES

1. BIMCO, ICS. "Manpower Report-The global supply and demand for seafarers. *Exec Summ*. Published online 2015:6. <http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16>
2. Telemedicine: revolutionising healthcare for seafarers. Accessed August 10, 2019. <https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/>
3. Lefkowitz RY, Redlich CA, Mph MDS. Injury , illness , and disability risk in American seafarers. *Am J Ind Med*. 2018;61:120-129. doi:10.1002/ajim.22802
4. IMO (International Maritime Organization). Accessed October 12, 2019. <https://business.un.org/en/entities/13>
5. Center for Maritime Safety and Health Studies. Published online 2019. Accessed October 12, 2019. https://www.cdc.gov/niosh/programs/cms/shs/port_operations.html
6. Mulić, Rosanda, Pero Vidan and RB. Comparative analysis of medical assistance to seafarers in the world and the republic of Croatia. *15th Int Conf Transp Sci*. Published online 2012:1-8. https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf

- 1
2
3 7. Roberts SE, Nielsen D, Kotłowski A, Jaremin B. Fatal accidents and injuries among
4 merchant seafarers worldwide. *Occup Med (Chic Ill)*. 2014;64:259-266.
5 doi:10.1093/occmed/kqu017
6
7
- 8 8. Borch DF, Hansen HL, Burr H, Jepsen JR. Surveillance of maritime deaths on board
9 Danish merchant ships , 1986 – 2009. Published online 2012:7-16.
10
11
- 12 9. Roberts SE, Hansen HL. An analysis of the causes of mortality among seafarers in the
13 British merchant fleet (1986-1995) and recommendations for their reduction. *Occup
14 Med (Chic Ill)*. 2002;52:195-202. doi:10.1093/occmed/52.4.195
15
16
- 17 10. Berg HP. Human Factors and Safety Culture in Maritime Safety (revised). *Mar Navig
18 Saf Sea Transp STCW, Marit Educ Train (MET), Hum Resour Crew Manning, Marit
19 Policy, Logist Econ Matters*. 2013;7(3):107-115. doi:10.12716/1001.07.03.04
20
21
22
- 23 11. Carter T. Mapping the knowledge base for maritime health: 1 historical perspective.
24 *Int Marit Health*. 2011;62(4):210-216.
25
26
- 27 12. Carter T. Mapping the knowledge base for maritime health: 2. a framework for
28 analysis. *Int Marit Health*. 2011;62(4):217-223. Accessed October 12, 2019.
29 <http://www.ncbi.nlm.nih.gov/pubmed/22544496>
30
31
- 32 13. Carter T. Mapping the knowledge base for maritime health: 3 illness and injury in
33 seafarers. *Int Marit Health*. 2011;62(4):224-240.
34
35
- 36 14. Carter T. Mapping the knowledge base for maritime health: 4 safety and performance
37 at sea. *Int Marit Health*. 2011;62(4):236-244. Accessed October 12, 2019.
38 <http://www.ncbi.nlm.nih.gov/pubmed/22544498>
39
40
- 41 15. Lefkowitz RY, Slade MD, Redlich CA. "Injury, illness, and work restriction in merchant
42 seafarers." *Am J Ind Med*. 2015;58(6):688-696. doi:10.1002/ajim.22459
43
44
- 45 16. Hannerz H. Hospitalisations among seafarers on merchant ships. *Occup Env Med*.
46 2005;62:145-150. doi:10.1136/oem.2004.014779
47
48
- 49 17. Kaerlev L, Jensen A, Nielsen PS, Olsen J, Hannerz H, Tüchsen F. Hospital contacts for
50 injuries and musculoskeletal diseases among seamen and fishermen : A population-
51 based cohort study. *BioMed Cent*. 2008;9:1-9. doi:10.1186/1471-2474-9-8
52
53
- 54 18. Herttua K, Gerdøe- S, Vork JC, Nielsen JB. Age and nationality in relation to injuries
55
56
57

- 1
2
3 at sea among officers and non- - officers : a study based on contacts from ships to
4 Telemedical Assistance Service in Denmark. *BMJ Open*. 2019;9:1-7.
5 doi:10.1136/bmjopen-2019-034502
6
7
8
9 19. Oldenburg M, Jensen HJ. Stress and strain among seafarers related to the
10 occupational groups. *Int J Environ Res Public Health*. 2019;16(7).
11 doi:10.3390/ijerph16071153
12
13
14 20. Oldenburg M, Jensen HJ, Latza U, Baur X. Seafaring stressors aboard merchant and
15 passenger ships. *Int J Public Health*. 2009;54(2):96-105. doi:10.1007/s00038-009-
16 7067-z
17
18
19 21. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication
20 in providing maritime medical assistance. *Int Marit Health*. 2016;67(4):187-195.
21 doi:10.5603/imh.2016.0036
22
23
24 22. Ehara M, Muramatsu S, Sano Y, Takeda S, Hisamune S. The tendency of diseases
25 among seamen during the last fifteen years in Japan. *Ind Health*. 2006;44(1):155-
26 160. doi:10.2486/indhealth.44.155
27
28
29
30 23. Nittari G, Tomassoni D, Di Canio M, et al. Overweight among seafarers working on
31 board merchant ships. *BMC Public Health*. 2019;19(1):1-8. doi:10.1186/s12889-018-
32 6377-6
33
34
35 24. Siegrist J, Rodel A. Work stress and health risk behavior. *Scand J Work Env Heal*.
36 2006;32(6):473-481. doi:10.5271/sjweh.1052
37
38
39 25. STCW. International Convention on Standards of Training, Certification and
40 Watchkeeping for Seafarers. IMO. Published 1995. Accessed May 2, 2020.
41 [http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-](http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx)
42 [convention.aspx](http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx)
43
44
45
46 26. Leino P. Symptoms of stress predict musculoskeletal disorders. *J Epidemiol*
47 *Community Health*. 1989;43(3):293-300. doi:10.1136/jech.43.3.293
48
49
50 27. Lim SK, Yoo SJ, Koo DL, et al. Stress and sleep quality in doctors working on-call
51 shifts are associated with functional gastrointestinal disorders. *World J Gastroenterol*.
52 2017;23(18):3330-3337. doi:10.3748/wjg.v23.i18.3330
53
54
55 28. Kivimäki M, Kawachi I. Work Stress as a Risk Factor for Cardiovascular Disease. *Curr*
56
57
58
59
60

- 1
2
3 *Cardiol Rep.* 2015;17(9). doi:10.1007/s11886-015-0630-8
4
5
6 29. Virtanen M, Heikkilä K, Jokela M, et al. Long working hours and coronary heart
7 disease: A systematic review and meta-analysis. *Am J Epidemiol.* 2012;176(7):586-
8 596. doi:10.1093/aje/kws139
9
10
11 30. Shin K, Chung Y, Kwon AY. The Effect of Long Working Hours on Cerebrovascular and
12 Cardiovascular Disease ; A Case-Crossover Study. 2017;761(December 2016):753-
13 761. doi:10.1002/ajim.22688.
14
15
16 31. Boivin DB, Boudreau P. Impacts of shift work on sleep and circadian rhythms. *Pathol*
17 *Biol.* 2014;62(5):292-301. doi:10.1016/j.patbio.2014.08.001
18
19
20 32. Hermansson J, Hallqvist J, Karlsson B, Knutsson A, Gådin KG. Shift work, parental
21 cardiovascular disease and myocardial infarction in males. *Occup Med (Chic Ill).*
22 2018;68(2):120-125. doi:10.1093/occmed/kqy008
23
24
25 33. Steptoe A, Kivimäki M. Stress and cardiovascular disease. *Nat Rev Cardiol.*
26 2012;9(6):360-370. doi:10.1038/nrcardio.2012.45
27
28
29 34. Li J, Zhang M, Loerbroks A, Angerer P, Siegrist J. Work stress and the risk of
30 recurrent coronary heart disease events: A systematic review and meta-analysis. *Int*
31 *J Occup Med Environ Health.* 2015;28(1):8-19. doi:10.2478/s13382-014-0303-7
32
33
34
35 35. Dragano N, Siegrist J, Nyberg ST, et al. Effort-Reward Imbalance at Work and
36 Incident Coronary Heart Disease: A Multicohort Study of 90,164 Individuals.
37 *Epidemiology.* 2017;28(4):619-626. doi:10.1097/EDE.0000000000000666
38
39
40 36. Sara JD, Prasad M, Eleid MF, Zhang M, Jay Widmer R, Lerman A. Association between
41 work-related stress and coronary heart disease: A review of prospective studies
42 through the job strain, effort-reward balance, and organizational justice models. *J Am*
43 *Heart Assoc.* 2018;7(9):1-15. doi:10.1161/JAHA.117.008073
44
45
46
47 37. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work
48 stress in the etiology of coronary heart disease - A meta-analysis. *Scand J Work*
49 *Environ Heal.* 2006;32(6):431-442. doi:10.5271/sjweh.1049
50
51
52 38. Jaremin B KE. Myocardial infarction (MI) at the work-site among Polish seafarers. The
53 risk and the impact of occupational factors. *Int Marit Heal.* 2003;54(1-4):26-39.
54
55
56
57
58
59
60

- 1
2
3 39. Filikowski J, Rzepiak M, Renke W, Winnicka A SD. Selected risk factors of ischemic
4 heart disease in Polish seafarers. Preliminary report. *Int Marit Heal*. 2003;54(1-4):40-
5 46.
6
7
8 40. Caruso G. "Do seafarers have sunshine." 8th International Symposium on Maritime
9 Health (ISMH) Book of abstracts. Published online 2005.
10
11
12 41. Laraqui O, Manar N, Laraqui S, et al. Prevalence of skin diseases amongst Moroccan
13 fishermen. *Int Marit Health*. 2018;69(1):22-27. doi:10.5603/IMH.2018.0004
14
15
16 42. Meyer G, Siekmann H, Feister U, Felten C HJ. Measurement of sunlight exposure in
17 seafaring [Ermittlung der natürlichen UV-Strahlenexposition in der Seeschiffahrt]. 50.
18 Jahrestagung der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin
19 (DGAUM). *Eur J Dermatol*. Published online 2010:434-436.
20
21
22
23 43. Oldenburg M, Kuechmeister B, Ohnemus U, Baur X, Moll I. Extrinsic skin ageing
24 symptoms in seafarers subject to high work-related exposure to UV radiation. *Eur J*
25 *Dermatology*. 2013;23(5):663-670. doi:10.1684/ejd.2013.2142
26
27
28
29 44. Jensen OC, Sørensen JF, Canals ML, Hu YP, Nikolic N TM. Incidence of self-reported
30 occupational injuries in seafaring — an international study. *Occup Med*.
31 2004;54(8):548-555. doi:10.1093/occmed/kqh090
32
33
34 45. Harrington JM. Health effects of shift work and extended hours of work. *Occup*
35 *Environ Med*. 2001;58(1):68-72.
36
37
38 46. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with
39 long working hours: A review of the current position. *Occup Environ Med*.
40 1997;54(6):367-375. doi:10.1136/oem.54.6.367
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 **Legends of the figures**
4

5 Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n =
6 338)
7

8
9 Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to
10 2019 (n = 85)
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

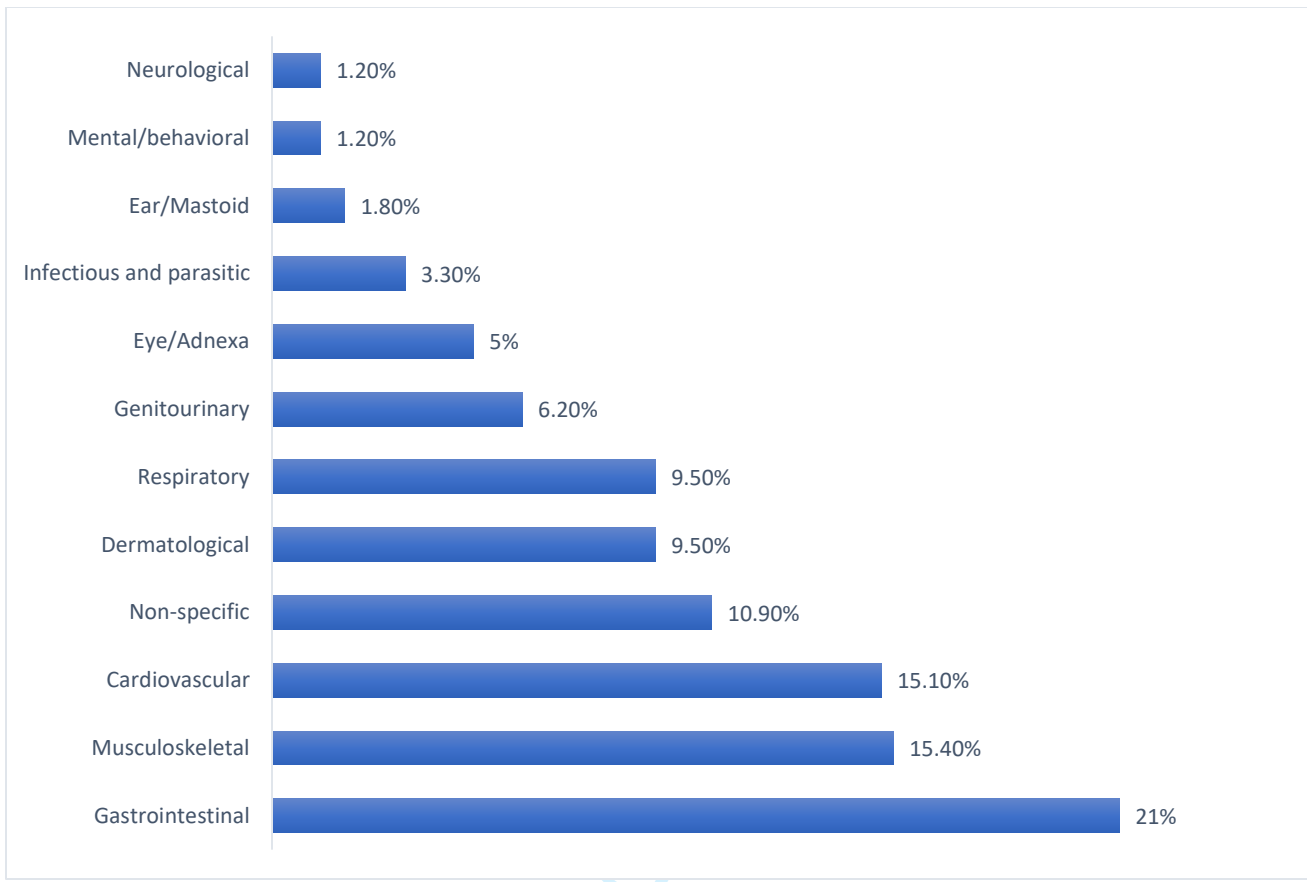


Figure 1

view only

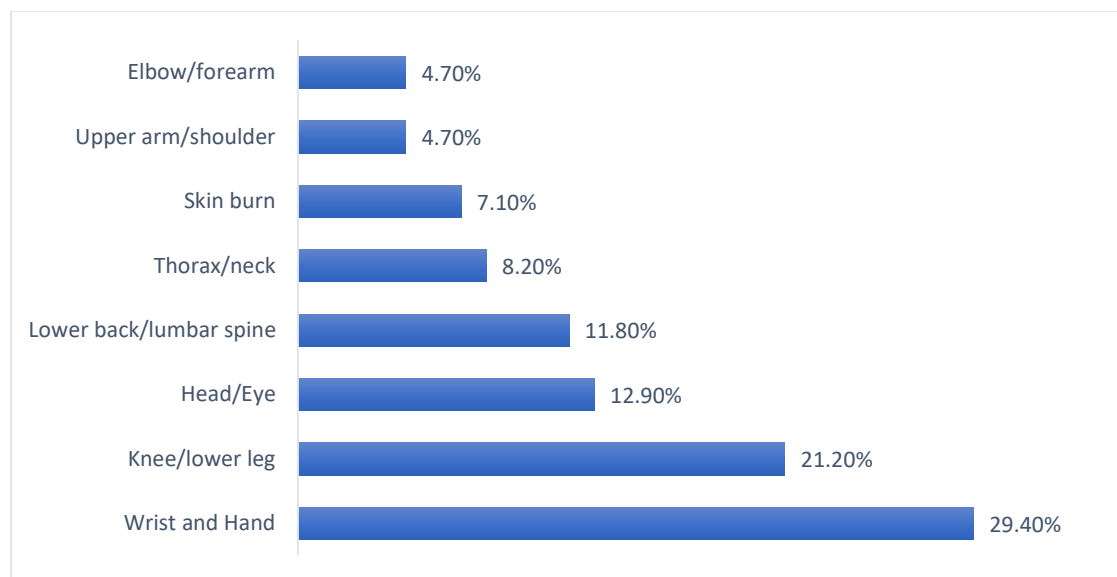


Figure 2

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 (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	5&6 6
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 (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	7, 8, 9,10
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.

BMJ Open

Incidence of occupational injuries and diseases among seafarers

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044633.R2
Article Type:	Original research
Date Submitted by the Author:	25-Jan-2021
Complete List of Authors:	Sagaro, Getu Gamo; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences; University of Camerino Dicanio, Marzio; Research Department, International Radio Medical Centre (CIRM), Battineni, Gopi ; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences Samad, Marc; CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille Amenta, Francesco; Università degli Studi di Camerino Scuola di Scienze del Farmaco e dei Prodotti della Salute, Telemedicine and Telepharmacy Centre
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Health informatics, Cardiovascular medicine, Occupational and environmental medicine
Keywords:	Epidemiology < TROPICAL MEDICINE, EPIDEMIOLOGY, Epidemiology < INFECTIOUS DISEASES, OCCUPATIONAL & INDUSTRIAL MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Incidence of occupational injuries and diseases among seafarers

Getu Gamo Sagaro^{1}, Marzio Dicario², Gopi Battineni¹, Marc Abdul Samad³ and Francesco Amenta^{1,2}*

¹Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences, University of Camerino, 62032 Camerino, Italy

²Research Department, Internazionale Radio Medical Center (C.I.R.M), 00144 Rome, Italy

³CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille, France

Corresponding Author:

Getu Gamo Sagaro (Ph.D.)
Telemedicine and Telepharmacy Center
School of Medicinal and Health Products Sciences,
University of Camerino
62032 Camerino MC, Italy
E-mail: getugamo.sagaro@unicam.it

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, respectively¹. 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 galley³. 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 workers⁵. Sailing seafarers have a one in eleven chance of being injured on duty on board⁶, 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 manufacturing⁷. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore⁸. 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 Britain⁹. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km¹⁰.

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 outcomes¹¹⁻¹³. 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 activities¹⁴. 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 hours¹⁹. For instance, workers in the engine room are exposed to work-

1
2
3 related risks such as noise, vibration, and heat or pollutants during their working hours^{19,20}.
4 In contrast, people working in the deck, as well as in the galley, are potentially exposed to
5 different work-related risks¹⁹. Because of the different areas of activity and associated
6 burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study
7 on the incidence rates of injury and disease by rank and worksite of seafarers would provide
8 information for prevention strategies such as resource allocation, prioritizing training areas,
9 improving the medicine chests on board, and access to telemedicine consultation to reduce
10 injury and disease at the workplace.
11
12
13
14
15

16 The present study aimed to analyze the incidence rates of reported occupational diseases and
17 injuries among seafarers by worksite and rank groups. This work provides factual information
18 on the rate of diseases and injuries between the worksite group as well as the rank. The
19 results obtained can be used to prioritize occupational health risks and guide the development
20 of preventative measures onboard container ships.
21
22
23

24 **2. METHODS**

25 **2.1. Study design, data source, and collection procedure**

26
27
28 We employed a retrospective study design and received data from the Centro Internazionale
29 Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M. is the Italian
30 Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest and best
31 known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than 100,000
32 seafarers onboard ships²¹. CMA CGM S.A. is a French container transport and shipping
33 company. It is a leading shipping group globally, using 200 shipping routes between 420 ports
34 in 150 different countries. In this particular study, the data source we used was reported
35 diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome. CMA CGM
36 S.A. shipping company made a contractual agreement with C.I.R.M. in January 2016 to
37 identify new approaches to provide high-quality telemedical assistance for seafarers. In view
38 of this agreement, data provided for medical assistance on the company's board ships are
39 more detailed and, therefore, can be used for a basic epidemiological analysis.
40
41
42
43
44
45
46
47
48

49 Work-related diseases are diseases predominantly due to physical, chemical, and biological
50 factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M.
51 database according to the World Health Organization (WHO) International Classification of
52 Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden,
53 unexpected, and unwanted forceful event due to an external cause's onboard ships. In the
54
55
56
57
58
59
60

1
2
3 C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version
4 (chapter XIX, S00-S99, and T00-T98).
5
6

7 The classification of both diseases and occupational injuries was made according to the prompt
8 diagnosis and recorded medical datasets in the C.I.R.M. database. The injury and disease
9 rates measured were based on the contacts from onboard container ships to the Telemedical
10 Maritime Assistance Service (TMAS) in Rome. Any contact for medical requests from ships to
11 the C.I.R.M. with injuries or cases of illness with important patient data, including age, sex,
12 job, rank, the nationality of the patient, ship flag, ship name, date of medical event that
13 occurred, anatomic location of the injury, diagnosis, treatment provided, the patient follow-
14 up schedule and other relevant information are registered in the database. Hence, we got
15 access to occupational injuries and diseases with seafarers' rank and job from the TMAS
16 database for this particular study.
17
18
19
20
21
22

23 An estimated total number of at-risk seafarer population was calculated by multiplying the
24 number of vessels during the study period by the average number of crew members per
25 vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an
26 average size of 20 crew members per ship³. The CMA CGM shipping company handles only
27 container ships, with an average of 25 crew members per ship. Regarding rank distribution
28 per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck
29 workers, thirteen engine workers and two galleys (catering) workers are in service per vessel.
30 The average number of the crew size, their rank as well as worksite distribution per large
31 vessel based on the knowledge of industry norm were calculated.
32
33
34
35
36
37

38 The number of CMA CGM container ships contracted over four years, from January 2016 to
39 December 31, 2019, was 539. An estimated number of the total at-risk seafarer population
40 for worksite and rank was determined by multiplying the total number of vessels over four
41 years by occupation and rank distribution per ship. The total number of seafarers at risk was
42 adjusted proportionally to the number of seafarers in the dataset for whom information on
43 occupation and rank was available.
44
45
46

47 **2.2. Statistical analysis**

48

49 Descriptive statistics such as mean and standard deviation (SD) of age, frequency, and
50 percentage of injuries by anatomic location and types of diseases were done to evaluate the
51 distribution of reported occupational injuries and diseases in seafarers with injuries and
52 diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and
53 engine ratings, and galley). The worksite was also categorized into three groups, including
54
55
56
57
58
59
60

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, ^aIRR calculated as the rate of non-officer/rate of officer, ^bDashes 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).

For peer review only

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

^bDashes indicate no case or the rate that was not performed.

1
2
3 The IRRs for deck workers versus engine workers', deck workers versus galley workers', and
4 engine workers versus galley workers were calculated and presented in Table 4. As a result,
5 deck workers were more likely than engine workers to have reported gastrointestinal (IRR =
6 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62),
7 and musculoskeletal (IRR = 2.14) disorders. Also, deck workers were more likely than engine
8 workers to be injured in the wrist and hand (IRR = 3.25)(Table 4).
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

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, ^bDashes indicate the comparison that was not performed, Abbreviation: N/A, not applicable.

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 USA¹⁵, 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%), and cardiovascular disorders (15%). Similar findings were reported in a Japanese study²², 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 USA³, 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 workers²⁰ 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 problems²⁴ and gastrointestinal disorders²⁵. 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,

1
2
3 loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk
4 factors^{28,29}. This study also reported the same rate of dermatological disorders for the deck
5 (IR = 3.96) and galley (IR = 3.96) workers. However, this could be due to the small number
6 of cases among galley workers, and even the estimated non-cases of galley workers are not
7 comparable in number to deck workers' non-cases. Consequently, 95% of the confidence
8 interval was wider for the case rate among the galley workers. The IRR results in the
9 comparison made between the workers on deck and in the galley were also not statistically
10 significant ($p = 1.044$) on this matter. Further studies are needed to measure the effect of
11 differences in the workplace of deck and galley workers on dermatological disease rates.
12

13
14
15
16
17 Angina pectoris (39% of all CVD diagnoses) was the most frequently reported cardiovascular
18 disorders in this study. As for cardiovascular disorders, it could be related to lifestyle,
19 especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the
20 board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were
21 overweight and obese, respectively³⁰. This finding suggests that in seafarer's CVD risk factors
22 are higher compared to ashore workers. We found that cardiovascular (IR = 6.06) disorders
23 were the second most common diseases for deck workers and deck workers were also more
24 likely than engine worker to have reported cardiovascular diseases (IRR = 3.26). This might
25 be due to work-related stress because deck workers have high work-related stress due to
26 sleep interruption, high job demands, night shift work, and intense activity than engine
27 workers. A study reported that work related stress was a risk factor for cardiovascular
28 diseases³¹. Long working hours are contributing factors to work-related stress, and it is logical
29 to expect an association between long hours and cardiovascular disorders^{32,33}. Studies have
30 also shown that night shift work had adverse effects on health and risk factors for the
31 development of chronic diseases such as cardiovascular diseases^{19,34,35}. The relationship
32 between stress and coronary heart disease are considered to be linked to multiple and
33 protracted increases in heart rate and blood pressure resulting from neuroendocrine
34 activation³⁶⁻³⁹. Other studies have reported that work-related stress can increase the
35 cardiovascular risk of workers⁴⁰⁻⁴². On the other hand, cardiovascular diseases and metabolic
36 disorders are stress-related diseases⁴³.
37
38
39
40
41
42
43
44
45
46
47

48
49 The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period.
50 The injury rate for non-officers and officers were significantly differed [IRR: 1.75 (95% CI) =
51 1.75 – 3.10]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and
52 lower leg (21%). Our results agree with the study conducted in the Danish-flagged merchant
53 fleet¹⁸, which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover,
54
55
56
57

1
2
3 this study revealed that non-officers were more likely than officers to be injured (IRR = 1.75).
4 This finding was in agreement with the previous studies^{17,3,44}. Non-officer work is
5 characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating
6 machinery such as cranes and drilling towers, and steering the ship at sea^{20,23}. The non-officer
7 work is also physically challenging^{19,20,23} and must be carried out regardless of weather
8 conditions. This could explain why non-officers have a higher rate of injuries than officers.
9
10
11

12
13 The present study has shown that the deck workers had higher rates of overall reported
14 injuries (IR = 8.69) compared to the engine (IR = 4.35) workers. These results are consistent
15 with those of the study conducted in the USA¹⁵. We found also the injury rate for deck workers
16 and engine workers were significantly differed [IRR: 1.99 (95% CI) =1.21 – 3.34]. Similarly,
17 deck workers were more likely than engine workers to be injured in the wrist and hand (IRR
18 = 3.25), as shown in Table 4. A study conducted in Danish Fleet seafarers⁴⁴ reported that
19 deck workers had a relatively low risk for injuries compared to machine (engine) workers.
20 The difference could be due to methodological differences. The study on seafarers in the
21 Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to
22 determine incidence rates and incidence rate ratios in the Danish fleet, were not consistent
23 with our study. Deck workers, particularly deck ratings, perform physical works such as
24 mooring and unmooring the ship, loading, and unloading cargo²³. Moreover, deck workers
25 have a shorter sleeping time and sleep interruptions more often than engine workers because
26 they are engaged in the surveillance system with frequent irregular operations. These include
27 monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs
28 and maintenance work in the deck area^{19,20,23}. Hence, night shift work, long working hours,
29 short average sleep time, and physical stress are important factors contributing to the high
30 rates of injuries/accidents at sea^{10,19,45,46}.
31
32
33
34
35
36
37
38
39
40

41 **Strengths and limitations**

42
43 This study measured the incidence rates of reported injury and disease to TMAS for container
44 ships. Most of the previous studies on diseases and injuries among seafarers were focused on
45 the number of cases. As far as we know, this study is the first study to measure the
46 contribution of differences in rank and job to the rates of injury and disease of seafarers
47 onboard container ships. Limitations of this study are: 1). We used an estimated average
48 number of seafarers per ship in the analysis, although we took into account different
49 assumptions, including the number of vessels, ships active at sea, number of crew members
50 per ship, and the length of stay of seafarers on board for the accuracy of the estimate.
51 Consequently, the incidence rate may be underestimated or overestimated. 2). Data from
52
53
54
55
56
57
58
59
60

1
2
3 patients with injuries and cases of disease contained descriptions such as age and gender,
4 but we had no descriptions of these data on the total at-risk seafarer population. Hence, we
5 have not determined the rates and incidence rate ratios of the diseases and injuries by
6 seafarers' age and sex. 3). Patient data on both injury and diagnosis were compiled according
7 to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not
8 on mechanisms of injury or potential physical hazards related to injured cases. As a result,
9 we have not stratified injuries by mechanisms of injury or occupational hazards to highlight
10 priority areas and recommend preventative measures. 4). We did not have descriptions of
11 data types such as socio-demographic variables and another exposure status of the total
12 seafarer population at risk. In this respect, we have not determined the risk factors for injury
13 and disease to propose further prevention strategies. Furthermore, this study is a
14 retrospective study and limited to the variables available in the dataset. Finally, our study is
15 limited to container ships and does not represent other types of ships at sea. Hence, the
16 results do not reflect seafarers working on other types of ships.

25 **CONCLUSION**

26
27 The results of this study were based on the medical events (diseases and occupational
28 injuries) of seafarers while working on board container ships. Non-officers had significantly
29 higher rates of reported gastrointestinal, musculoskeletal, and dermatological disorders
30 compared to officers. Also, non-officers were more likely than officers to be injured in the
31 knee and lower leg. Deck workers had significantly higher rates for dermatological,
32 cardiovascular, musculoskeletal, respiratory, and gastrointestinal disorders when compared
33 to engine workers. Deck workers were more likely than engine workers to be injured in the
34 wrist and hand. In general, the total reported injury and disease rates for non-officers were
35 significantly higher compared to officers. The same is true for deck workers compared to
36 engine workers. Hence, this study suggests the need for rank and work site-specific
37 prevention strategies to reduce injury and disease rates at the workplace. Future studies
38 should consider the risk factors for injury and disease among seafarers in order to propose
39 further preventive measures.

48 **Contributors**

49
50 GGS.: conceived and designed the study, performed analysis, methodology, interpreted the
51 data and results, and drafted the initial manuscript. MD: extracted data and assisted with
52 the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted
53
54
55
56
57
58
59

1
2
3 the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and
4 approved the study. All authors approved the final version of the manuscript.
5
6
7

8 **Funding:** This work was supported by the International Transport Workers Federation (ITF)
9 Trust, London, UK, under grant number 558 to C.I.R.M. Institutional funding of the University of
10 Camerino, Italy, supported Ph.D. bursaries to GGS and GB.
11
12
13

14 **Conflict of interests**

15
16 The authors declared that they have no conflict of interest.
17
18
19
20
21
22
23
24
25

26 **Ethical approval**

27
28 The study has been reviewed and approved by the Scientific/Ethics Committee of the C.I.R.M.
29 Foundation.
30
31

32 **Patient consent for publication:** Not required
33

34 **Data availability statement:** No additional data available
35
36

37 **ORCID iD**

38
39 Getu Gamo Sagaro <https://orcid.org/0000-0002-5983-0266>
40

41 Gopi Battenini <https://orcid.org/0000-0003-0603-2356>
42
43

44 Francesco Amenta <https://orcid.org/0000-0002-0555-1034>
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

REFERENCES

1. BIMCO, ICS. "Manpower Report-The global supply and demand for seafarers. *Exec Summ*. Published online 2015:6. <http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16>
2. Telemedicine: revolutionising healthcare for seafarers. Accessed August 10, 2019. <https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/>
3. Lefkowitz RY, Redlich CA, Mph MDS. Injury , illness , and disability risk in American seafarers. *Am J Ind Med*. 2018;61:120-129. doi:10.1002/ajim.22802
4. IMO (International Maritime Organization). Accessed October 12, 2019. <https://business.un.org/en/entities/13>
5. Center for Maritime Safety and Health Studies. Published online 2019. Accessed October 12, 2019. https://www.cdc.gov/niosh/programs/cmshs/port_operations.html
6. Mulić, Rosanda, Pero Vidan and RB. Comparative analysis of medical assistance to seafarers in the world and the republic of Croatia. *15th Int Conf Transp Sci*. Published online 2012:1-8. https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf
7. Roberts SE, Nielsen D, Kotłowski A, Jaremin B. Fatal accidents and injuries among merchant seafarers worldwide. *Occup Med (Chic Ill)*. 2014;64:259-266. doi:10.1093/occmed/kqu017
8. Borch DF, Hansen HL, Burr H, Jepsen JR. Surveillance of maritime deaths on board Danish merchant ships , 1986 – 2009. Published online 2012:7-16.
9. Roberts SE, Hansen HL. An analysis of the causes of mortality among seafarers in the British merchant fleet (1986-1995) and recommendations for their reduction. *Occup Med (Chic Ill)*. 2002;52:195-202. doi:10.1093/occmed/52.4.195
10. Berg HP. Human Factors and Safety Culture in Maritime Safety (revised). *Mar Navig Saf Sea Transp STCW, Marit Educ Train (MET), Hum Resour Crew Manning, Marif Policy, Logist Econ Matters*. 2013;7(3):107-115. doi:10.12716/1001.07.03.04
11. Carter T. Mapping the knowledge base for maritime health: 1 historical perspective.

- 1
2
3 *Int Marit Health*. 2011;62(4):210-216.
4
5
6 12. Carter T. Mapping the knowledge base for maritime health: 2. a framework for
7 analysis. *Int Marit Health*. 2011;62(4):217-223. Accessed October 12, 2019.
8 <http://www.ncbi.nlm.nih.gov/pubmed/22544496>
9
10
11 13. Carter T. Mapping the knowledge base for maritime health: 3 illness and injury in
12 seafarers. *Int Marit Health*. 2011;62(4):224-240.
13
14
15 14. Carter T. Mapping the knowledge base for maritime health: 4 safety and performance
16 at sea. *Int Marit Health*. 2011;62(4):236-244. Accessed October 12, 2019.
17 <http://www.ncbi.nlm.nih.gov/pubmed/22544498>
18
19
20 15. Lefkowitz RY, Slade MD, Redlich CA. "Injury, illness, and work restriction in merchant
21 seafarers." *Am J Ind Med*. 2015;58(6):688-696. doi:10.1002/ajim.22459
22
23
24 16. Hannerz H. Hospitalisations among seafarers on merchant ships. *Occup Env Med*.
25 2005;62:145-150. doi:10.1136/oem.2004.014779
26
27
28 17. Kaerlev L, Jensen A, Nielsen PS, Olsen J, Hannerz H, Tüchsen F. Hospital contacts for
29 injuries and musculoskeletal diseases among seamen and fishermen : A population-
30 based cohort study. *BioMed Cent*. 2008;9:1-9. doi:10.1186/1471-2474-9-8
31
32
33 18. Herttua K, Gerdøe S, Vork JC, Nielsen JB. Age and nationality in relation to injuries
34 at sea among officers and non- - officers : a study based on contacts from ships to
35 Telemedical Assistance Service in Denmark. *BMJ Open*. 2019;9:1-7.
36 doi:10.1136/bmjopen-2019-034502
37
38
39
40 19. Oldenburg M, Jensen HJ. Stress and strain among seafarers related to the
41 occupational groups. *Int J Environ Res Public Health*. 2019;16(7).
42 doi:10.3390/ijerph16071153
43
44
45 20. Oldenburg M, Jensen HJ, Latza U, Baur X. Seafaring stressors aboard merchant and
46 passenger ships. *Int J Public Health*. 2009;54(2):96-105. doi:10.1007/s00038-009-
47 7067-z
48
49
50
51 21. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication
52 in providing maritime medical assistance. *Int Marit Health*. 2016;67(4):187-195.
53 doi:10.5603/imh.2016.0036
54
55
56
57
58
59
60

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
 - 26
 - 27
 - 28
 - 29
 - 30
 - 31
 - 32
 - 33
 - 34
 - 35
 - 36
 - 37
 - 38
 - 39
 - 40
 - 41
 - 42
 - 43
 - 44
 - 45
 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
22. Ehara M, Muramatsu S, Sano Y, Takeda S, Hisamune S. The tendency of diseases among seamen during the last fifteen years in Japan. *Ind Health*. 2006;44(1):155-160. doi:10.2486/indhealth.44.155
23. STCW. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers. IMO. Published 1995. Accessed May 2, 2020. <http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx>
24. Leino P. Symptoms of stress predict musculoskeletal disorders. *J Epidemiol Community Health*. 1989;43(3):293-300. doi:10.1136/jech.43.3.293
25. Lim SK, Yoo SJ, Koo DL, et al. Stress and sleep quality in doctors working on-call shifts are associated with functional gastrointestinal disorders. *World J Gastroenterol*. 2017;23(18):3330-3337. doi:10.3748/wjg.v23.i18.3330
26. Caruso G. "Do seafarers have sunshine." 8th International Symposium on Maritime Health (ISMH) Book of abstracts. Published online 2005.
27. Laraqui O, Manar N, Laraqui S, et al. Prevalence of skin diseases amongst Moroccan fishermen. *Int Marit Health*. 2018;69(1):22-27. doi:10.5603/IMH.2018.0004
28. Meyer G, Siekmann H, Feister U, Felten C HJ. Measurement of sunlight exposure in seafaring [Ermittlung der natürlichen UV-Strahlenexposition in der Seeschiffahrt]. 50. Jahrestagung der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin (DGAUM). *Eur J Dermatol*. Published online 2010:434-436.
29. Oldenburg M, Kuechmeister B, Ohnemus U, Baur X, Moll I. Extrinsic skin ageing symptoms in seafarers subject to high work-related exposure to UV radiation. *Eur J Dermatology*. 2013;23(5):663-670. doi:10.1684/ejd.2013.2142
30. Nittari G, Tomassoni D, Di Canio M, et al. Overweight among seafarers working on board merchant ships. *BMC Public Health*. 2019;19(1):1-8. doi:10.1186/s12889-018-6377-6
31. Kivimäki M, Kawachi I. Work Stress as a Risk Factor for Cardiovascular Disease. *Curr Cardiol Rep*. 2015;17(9). doi:10.1007/s11886-015-0630-8
32. Virtanen M, Heikkilä K, Jokela M, et al. Long working hours and coronary heart disease: A systematic review and meta-analysis. *Am J Epidemiol*. 2012;176(7):586-

- 1
2
3 596. doi:10.1093/aje/kws139
4
5
6 33. Shin K, Chung Y, Kwon ÆY. The Effect of Long Working Hours on Cerebrovascular and
7 Cardiovascular Disease ; A Case-Crossover Study. 2017;761(December 2016):753-
8 761. doi:10.1002/ajim.22688.
9
10
11 34. Boivin DB, Boudreau P. Impacts of shift work on sleep and circadian rhythms. *Pathol*
12 *Biol.* 2014;62(5):292-301. doi:10.1016/j.patbio.2014.08.001
13
14
15 35. Hermansson J, Hallqvist J, Karlsson B, Knutsson A, Gådin KG. Shift work, parental
16 cardiovascular disease and myocardial infarction in males. *Occup Med (Chic Ill)*.
17 2018;68(2):120-125. doi:10.1093/occmed/kqy008
18
19
20 36. Steptoe A, Kivimäki M. Stress and cardiovascular disease. *Nat Rev Cardiol*.
21 2012;9(6):360-370. doi:10.1038/nrcardio.2012.45
22
23
24 37. Li J, Zhang M, Loerbroks A, Angerer P, Siegrist J. Work stress and the risk of
25 recurrent coronary heart disease events: A systematic review and meta-analysis. *Int*
26 *J Occup Med Environ Health*. 2015;28(1):8-19. doi:10.2478/s13382-014-0303-7
27
28
29 38. Dragano N, Siegrist J, Nyberg ST, et al. Effort-Reward Imbalance at Work and
30 Incident Coronary Heart Disease: A Multicohort Study of 90,164 Individuals.
31 *Epidemiology*. 2017;28(4):619-626. doi:10.1097/EDE.0000000000000666
32
33
34
35 39. Sara JD, Prasad M, Eleid MF, Zhang M, Jay Widmer R, Lerman A. Association between
36 work-related stress and coronary heart disease: A review of prospective studies
37 through the job strain, effort-reward balance, and organizational justice models. *J Am*
38 *Heart Assoc*. 2018;7(9):1-15. doi:10.1161/JAHA.117.008073
39
40
41
42 40. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work
43 stress in the etiology of coronary heart disease - A meta-analysis. *Scand J Work*
44 *Environ Heal*. 2006;32(6):431-442. doi:10.5271/sjweh.1049
45
46
47 41. Jaremin B KE. Myocardial infarction (MI) at the work-site among Polish seafarers. The
48 risk and the impact of occupational factors. *Int Marit Heal*. 2003;54(1-4):26-39.
49
50
51 42. Filikowski J, Rzepliak M, Renke W, Winnicka A SD. Selected risk factors of ischemic
52 heart disease in Polish seafarers. Preliminary report. *Int Marit Heal*. 2003;54(1-4):40-
53 46.
54
55
56
57
58
59
60

- 1
2
3 43. Siegrist J, Rodel A. Work stress and health risk behavior. *Scand J Work Env Heal*.
4 2006;32(6):473-481. doi:10.5271/sjweh.1052
5
6
7 44. Jensen OC, Sørensen JF, Canals ML, Hu YP, Nikolic N TM. Incidence of self-reported
8 occupational injuries in seafaring — an international study. *Occup Med*.
9 2004;54(8):548-555. doi:10.1093/occmed/kqh090
10
11
12 45. Harrington JM. Health effects of shift work and extended hours of work. *Occup*
13 *Environ Med*. 2001;58(1):68-72.
14
15
16 46. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with
17 long working hours: A review of the current position. *Occup Environ Med*.
18 1997;54(6):367-375. doi:10.1136/oem.54.6.367
19
20
21
22
23
24
25

Legends of the figures

26
27
28
29 Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n =
30 338)
31

32
33 Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to
34 2019 (n = 85)
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

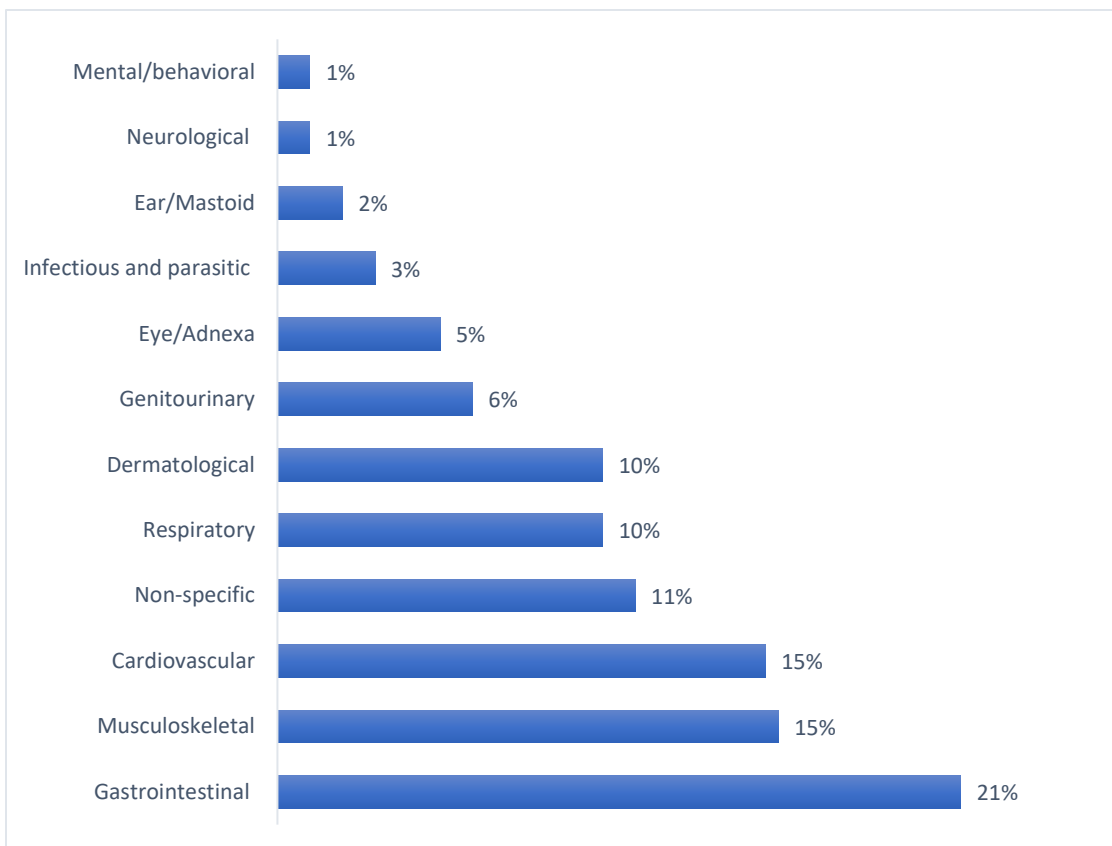


Figure 1

view only

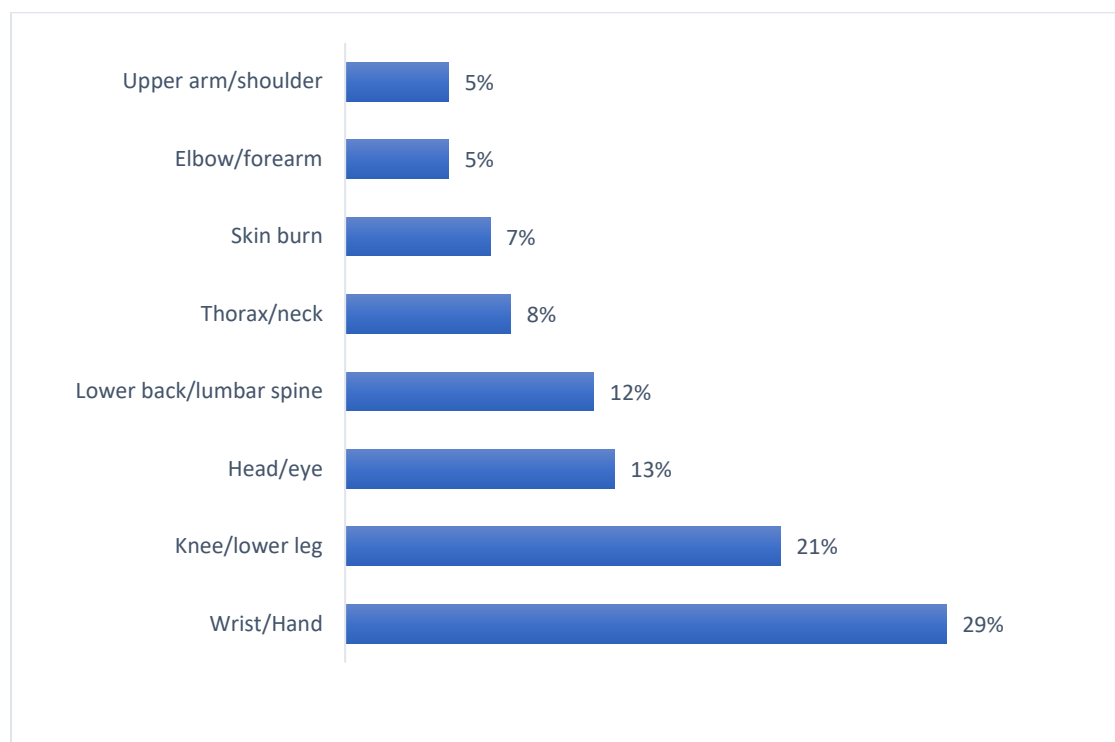


Figure 2

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 (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	5&6 6
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 (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	7, 8, 9,11 & 13
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.

BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2020-044633.R3
Article Type:	Original research
Date Submitted by the Author:	17-Feb-2021
Complete List of Authors:	Sagaro, Getu Gamo; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences Dicanio, Marzio; Research Department, International Radio Medical Centre (C.I.R.M.), Battineni, Gopi ; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences Samad, Marc; CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille Amenta, Francesco; University of Camerino, Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences; Research Department, International Radio Medical Center (C.I.R.M.), 00144
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Epidemiology, Health informatics, Cardiovascular medicine, Occupational and environmental medicine
Keywords:	Epidemiology < TROPICAL MEDICINE, EPIDEMIOLOGY, Epidemiology < INFECTIOUS DISEASES, OCCUPATIONAL & INDUSTRIAL MEDICINE

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

1
2
3 **Incidence of occupational injuries and diseases among seafarers: a**
4 **descriptive epidemiological study based on contacts from onboard ships to**
5 **the Italian Telemedical Maritime Assistance service in Rome, Italy**
6

7 *Getu Gamo Sagaro*^{1*}, *Marzio Dicario*², *Gopi Battineni*¹, *Marc Abdul Samad*³ and *Francesco*
8 *Amenta*^{1,2}
9

10
11
12 ¹Telemedicine and Telepharmacy Center, School of Medicinal and Health Products Sciences,
13 University of Camerino, 62032 Camerino, Italy
14

15
16 ²Research Department, Internazionale Radio Medical Center (C.I.R.M), 00144 Rome, Italy
17

18 ³CMA-CGM, Tour CMA CGM, 4 Quai d'Arenc, 13002 Marseille, France
19
20
21
22
23

24 **Corresponding Author:**
25

26 Getu Gamo Sagaro (Ph.D.)
27 Telemedicine and Telepharmacy Center
28 School of Medicinal and Health Products Sciences,
29 University of Camerino
30 62032 Camerino MC, Italy
31 E-mail: getugamo.sagaro@unicam.it
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

For peer review only

1. INTRODUCTION

In 2015, more than 1.6 million seafarers served worldwide, of which 774,000 and 873,500 were officers and ratings, respectively¹. 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 galley³. 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 workers⁵. Sailing seafarers have a one in eleven chance of being injured on duty on board⁶, 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 manufacturing⁷. Fatal occupational accidents in Danish seafarers onboard ships were 11.5 times higher than Danish male workers ashore⁸. 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 Britain⁹. The risk of death is 25 times higher for maritime transport than for air transport, according to the death accounts for every 100 km¹⁰.

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 outcomes¹¹⁻¹³. 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 activities¹⁴. 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 hours¹⁹. For instance, workers in the engine room are exposed to work-

1
2
3 related risks such as noise, vibration, and heat or pollutants during their working hours^{19,20}.
4 In contrast, people working in the deck, as well as in the galley, are potentially exposed to
5 different work-related risks¹⁹. Because of the different areas of activity and associated
6 burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study
7 on the incidence rates of injury and disease by rank and worksite of seafarers would provide
8 information for prevention strategies such as resource allocation, prioritizing training areas,
9 improving the medicine chests on board, and access to telemedicine consultation to reduce
10 injury and disease at the workplace.
11
12
13
14
15

16 The present study aimed to analyze the incidence rates of reported occupational diseases and
17 injuries among seafarers by worksite and rank groups. This work provides factual information
18 on the rate of diseases and injuries between the worksite group as well as the rank. The
19 results obtained can be used to prioritize occupational health risks and guide the development
20 of preventative measures onboard container ships.
21
22
23

24 **2. METHODS**

25 **2.1. Study design, data source, and collection procedure**

26
27
28
29
30 We employed a descriptive epidemiological study and received data from the Centro
31 Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.) database. C.I.R.M.
32 is the Italian Telemedical Maritime Assistance Service (TMAS) and represents one of the oldest
33 and best known TMAS worldwide. C.I.R.M. operates since 1935 and has assisted more than
34 100,000 seafarers onboard ships²¹. CMA CGM S.A. is a French container transport and
35 shipping company. It is a leading shipping group globally, using 200 shipping routes between
36 420 ports in 150 different countries. In this particular study, the data source we used was
37 reported diseases and injuries from onboard CMA CGM container ships to TMAS, in Rome.
38 CMA CGM S.A. shipping company made a contractual agreement with C.I.R.M. in January
39 2016 to identify new approaches to provide high-quality telemedical assistance for seafarers.
40 In view of this agreement, data provided for medical assistance on the company's board ships
41 are more detailed and, therefore, can be used for a basic epidemiological analysis.
42
43
44
45
46
47
48

49 Work-related diseases are diseases predominantly due to physical, chemical, and biological
50 factors associated with merchant seafaring occupations, and they are recorded in the C.I.R.M.
51 database according to the World Health Organization (WHO) International Classification of
52 Disease 10th revised version (ICD 10). An occupational injury is defined as a sudden,
53 unexpected, and unwanted forceful event due to an external cause's onboard ships. In the
54
55
56
57
58
59
60

1
2
3 C.I.R.M. database, injuries also are recorded according to the WHO ICD 10th revised version
4 (chapter XIX, S00-S99, and T00-T98).
5
6

7 The classification of both diseases and occupational injuries was made according to the prompt
8 diagnosis and recorded medical datasets in the C.I.R.M. database. The injury and disease
9 rates measured were based on the contacts from onboard container ships to the Italian
10 Telemedical Maritime Assistance Service (TMAS) in Rome. Any contact for medical requests
11 from ships to the C.I.R.M. with injuries or cases of illness with important patient data,
12 including age, sex, job, rank, the nationality of the patient, ship flag, ship name, date of
13 medical event that occurred, anatomic location of the injury, diagnosis, treatment provided,
14 the patient follow-up schedule and other relevant information are registered in the database.
15 Hence, we got access to occupational injuries and diseases with seafarers' rank and job from
16 the TMAS database for this particular study.
17
18
19
20
21
22

23 An estimated total number of at-risk seafarer population was calculated by multiplying the
24 number of vessels during the study period by the average number of crew members per
25 vessel. As a result, large ships, including general cargo, tankers, and bulk carriers, have an
26 average size of 20 crew members per ship³. The CMA CGM shipping company handles only
27 container ships, with an average of 25 crew members per ship. Regarding rank distribution
28 per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, ten deck
29 workers, thirteen engine workers and two galleys (catering) workers are in service per vessel.
30 The average number of the crew size, their rank as well as worksite distribution per large
31 vessel based on the knowledge of industry norm were calculated.
32
33
34
35
36
37

38 The number of CMA CGM container ships contracted over four years, from January 2016 to
39 December 31, 2019, was 539. In other words, 539 vessels represented the total number of
40 active ships onboard in four years (January 2016 to December 31, 2019), and due to this, we
41 determined the cumulative incidence rates. An estimated number of the total at-risk seafarer
42 population for worksite and rank was determined by multiplying the total number of vessels
43 over four years by occupation and rank distribution per ship. The total number of seafarers
44 at risk was adjusted proportionally to the number of seafarers in the dataset for whom
45 information on occupation and rank was available.
46
47
48
49

50 **2.2. Statistical analysis**

51

52 Descriptive statistics such as mean and standard deviation (SD) of age, frequency, and
53 percentage of injuries by anatomic location and types of diseases were done to evaluate the
54 distribution of reported occupational injuries and diseases in seafarers with injuries and
55
56
57

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, ^aIRR calculated as the rate of non-officer/rate of officer, ^bDashes 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).

For peer review only

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

^bDashes indicate no case or the rate that was not performed.

1
2
3 The IRRs for deck workers versus engine workers', deck workers versus galley workers', and
4 engine workers versus galley workers were calculated and presented in Table 4. As a result,
5 deck workers were more likely than engine workers to have reported gastrointestinal (IRR =
6 1.86), cardiovascular (IRR = 3.26), dermatological (IRR = 4.35), respiratory (IRR = 2.62),
7 and musculoskeletal (IRR = 2.14) disorders. Also, deck workers were more likely than engine
8 workers to be injured in the wrist and hand (IRR = 3.25)(Table 4).
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

For peer review only

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, ^bDashes indicate the comparison that was not performed, Abbreviation: N/A, not applicable.

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 USA¹⁵, 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%), and cardiovascular disorders (15%). Similar findings were reported in a Japanese study²², 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 USA³, 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 workers²⁰ 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 problems²⁴ and gastrointestinal disorders²⁵. 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,

1
2
3 loading, painting activities, and exposure to chemicals, UV radiation, and other skin risk
4 factors^{28,29}. This study also reported the same rate of dermatological disorders for the deck
5 (IR = 3.96) and galley (IR = 3.96) workers. However, this could be due to the small number
6 of cases among galley workers, and even the estimated non-cases of galley workers are not
7 comparable in number to deck workers' non-cases. Consequently, 95% of the confidence
8 interval was wider for the case rate among the galley workers. The IRR results in the
9 comparison made between the workers on deck and in the galley were also not statistically
10 significant ($p = 1.044$) on this matter. Further studies are needed to measure the effect of
11 differences in the workplace of deck and galley workers on dermatological disease rates.

12
13
14
15
16
17 Angina pectoris (39% of all CVD diagnoses) was the most frequently reported cardiovascular
18 disorders in this study. As for cardiovascular disorders, it could be related to lifestyle,
19 especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the
20 board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were
21 overweight and obese, respectively³⁰. This finding suggests that in seafarer's CVD risk factors
22 are higher compared to ashore workers. We found that cardiovascular (IR = 6.06) disorders
23 were the second most common diseases for deck workers and deck workers were also more
24 likely than engine worker to have reported cardiovascular diseases (IRR = 3.26). This might
25 be due to work-related stress because deck workers have high work-related stress due to
26 sleep interruption, high job demands, night shift work, and intense activity than engine
27 workers. A study reported that work related stress was a risk factor for cardiovascular
28 diseases³¹. Long working hours are contributing factors to work-related stress, and it is logical
29 to expect an association between long hours and cardiovascular disorders^{32,33}. Studies have
30 also shown that night shift work had adverse effects on health and risk factors for the
31 development of chronic diseases such as cardiovascular diseases^{19,34,35}. The relationship
32 between stress and coronary heart disease are considered to be linked to multiple and
33 protracted increases in heart rate and blood pressure resulting from neuroendocrine
34 activation³⁶⁻³⁹. Other studies have reported that work-related stress can increase the
35 cardiovascular risk of workers⁴⁰⁻⁴². On the other hand, cardiovascular diseases and metabolic
36 disorders are stress-related diseases⁴³.

37
38
39
40
41
42
43
44
45
46
47
48
49 The total reported injury rate was 6.31 per 1,000 seafarer-year over four years' study period.
50 The injury rate for non-officers and officers were significantly differed [IRR: 1.75 (95% CI) =
51 1.75 – 3.10]. Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and
52 lower leg (21%). Our results agree with the study conducted in the Danish-flagged merchant
53 fleet¹⁸, which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover,
54
55
56
57

1
2
3 this study revealed that non-officers were more likely than officers to be injured (IRR = 1.75).
4 This finding was in agreement with the previous studies^{17,3,44}. Non-officer work is
5 characterized by mooring, cleaning the ship, repairing broken cables and ropes, operating
6 machinery such as cranes and drilling towers, and steering the ship at sea^{20,23}. The non-officer
7 work is also physically challenging^{19,20,23} and must be carried out regardless of weather
8 conditions. This could explain why non-officers have a higher rate of injuries than officers.
9
10

11
12
13 The present study has shown that the deck workers had higher rates of overall reported
14 injuries (IR = 8.69) compared to the engine (IR = 4.35) workers. These results are consistent
15 with those of the study conducted in the USA¹⁵. We also found the injury rate for deck workers
16 and engine workers were significantly differed [IRR: 1.99 (95% CI) =1.21 – 3.34]. Similarly,
17 deck workers were more likely than engine workers to be injured in the wrist and hand (IRR
18 = 3.25), as shown in Table 4. A study conducted in Danish Fleet seafarers⁴⁴ reported that
19 deck workers had a relatively low risk for injuries compared to machine (engine) workers.
20 The difference could be due to methodological differences. The study on seafarers in the
21 Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to
22 determine incidence rates and incidence rate ratios in the Danish fleet, were not consistent
23 with our study. Deck workers, particularly deck ratings, perform physical works such as
24 mooring and unmooring the ship, loading, and unloading cargo²³. Moreover, deck workers
25 have a shorter sleeping time and sleep interruptions more often than engine workers because
26 they are engaged in the surveillance system with frequent irregular operations. These include
27 monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs
28 and maintenance work in the deck area^{19,20,23}. Hence, night shift work, long working hours,
29 short average sleep time, and physical stress are important factors contributing to the high
30 rates of injuries/accidents at sea^{10,19,45,46}.
31
32
33
34
35
36
37
38
39
40

41 **Strengths and limitations**

42
43 This study measured the incidence rates of reported injury and disease to TMAS for container
44 ships. Most of the previous studies on diseases and injuries among seafarers were focused on
45 the number of cases. As far as we know, this study is the first study to measure the
46 contribution of differences in rank and job to the rates of injury and disease of seafarers
47 onboard container ships. Limitations of this study are: 1). We used an estimated average
48 number of seafarers per ship in the analysis, although we took into account different
49 assumptions, including the number of vessels, ships active at sea, number of crew members
50 per ship, and the length of stay of seafarers on board for the accuracy of the estimate.
51 Consequently, the incidence rate may be underestimated or overestimated. 2). Data from
52
53
54
55
56
57
58
59
60

1
2
3 patients with injuries and cases of disease contained descriptions such as age and gender,
4 but we had no descriptions of these data on the total at-risk seafarer population. Hence, we
5 have not determined the rates and incidence rate ratios of the diseases and injuries by
6 seafarers' age and sex. 3). Patient data on both injury and diagnosis were compiled according
7 to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not
8 on mechanisms of injury or potential physical hazards related to injured cases. As a result,
9 we have not stratified injuries by mechanisms of injury or occupational hazards to highlight
10 priority areas and recommend preventative measures. 4). We did not have descriptions of
11 data types such as socio-demographic variables and another exposure status of the total
12 seafarer population at risk. In this respect, we have not determined the risk factors for injury
13 and disease to propose further prevention strategies. Furthermore, this study is a
14 retrospective study and limited to the variables available in the dataset. Finally, our study is
15 limited to container ships and does not represent other types of ships at sea. Hence, the
16 results do not reflect seafarers working on other types of ships.

24 25 **CONCLUSION**

26
27 The results of this study were based on the medical events (diseases and occupational
28 injuries) of seafarers while working on board container ships. Non-officers had significantly
29 higher rates of reported gastrointestinal, musculoskeletal, and dermatological disorders
30 compared to officers. Also, non-officers were more likely than officers to be injured in the
31 knee and lower leg. Deck workers had significantly higher rates for dermatological,
32 cardiovascular, musculoskeletal, respiratory, and gastrointestinal disorders when compared
33 to engine workers. Deck workers were more likely than engine workers to be injured in the
34 wrist and hand. In general, the total reported injury and disease rates for non-officers were
35 significantly higher compared to officers. The same is true for deck workers compared to
36 engine workers. Hence, this study suggests the need for rank and work site-specific
37 prevention strategies to reduce injury and disease rates at the workplace. Future studies
38 should consider the risk factors for injury and disease among seafarers in order to propose
39 further preventive measures.

46 47 **Contributors**

48
49 GGS.: conceived and designed the study, performed analysis, methodology, interpreted the
50 data and results, and drafted the initial manuscript. MD: extracted data and assisted with
51 the preparation of the manuscript. GB.: contributed to the data collection. MAS: interpreted

1
2
3 the data and involved in the preparation of the manuscript. FA: guided, edited, reviewed, and
4 approved the study. All authors approved the final version of the manuscript.
5
6
7

8 **Funding:** This work was supported by the International Transport Workers Federation (ITF)
9 Trust, London, UK, under grant number 558 to C.I.R.M. Institutional funding of the University of
10 Camerino, Italy, supported Ph.D. bursaries to GGS and GB.
11
12
13

14 **Conflict of interests**

15
16 The authors declared that they have no conflict of interest.
17
18
19
20
21
22
23
24
25

26 **Ethical approval**

27
28 The study has been reviewed and approved by the Scientific/Ethics Committee of the C.I.R.M.
29 Foundation.
30
31

32 **Patient consent for publication:** Not required.
33

34 **Data availability statement:** No additional data available
35

36 **ORCID iD**

37
38
39 Getu Gamo Sagaro <https://orcid.org/0000-0002-5983-0266>
40

41
42 Gopi Battenini <https://orcid.org/0000-0003-0603-2356>
43

44
45 Francesco Amenta <https://orcid.org/0000-0002-0555-1034>
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

REFERENCES

1. BIMCO, ICS. "Manpower Report-The global supply and demand for seafarers. *Exec Summ*. Published online 2015:6. <http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16>
2. Telemedicine: revolutionising healthcare for seafarers. Accessed August 10, 2019. <https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/>
3. Lefkowitz RY, Redlich CA, Mph MDS. Injury , illness , and disability risk in American seafarers. *Am J Ind Med*. 2018;61:120-129. doi:10.1002/ajim.22802
4. IMO (International Maritime Organization). Accessed October 12, 2019. <https://business.un.org/en/entities/13>
5. Center for Maritime Safety and Health Studies. Published online 2019. Accessed October 12, 2019. https://www.cdc.gov/niosh/programs/cmshs/port_operations.html
6. Mulić, Rosanda, Pero Vidan and RB. Comparative analysis of medical assistance to seafarers in the world and the republic of Croatia. *15th Int Conf Transp Sci*. Published online 2012:1-8. https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf
7. Roberts SE, Nielsen D, Kotłowski A, Jaremin B. Fatal accidents and injuries among merchant seafarers worldwide. *Occup Med (Chic Ill)*. 2014;64:259-266. doi:10.1093/occmed/kqu017
8. Borch DF, Hansen HL, Burr H, Jepsen JR. Surveillance of maritime deaths on board Danish merchant ships , 1986 – 2009. Published online 2012:7-16.
9. Roberts SE, Hansen HL. An analysis of the causes of mortality among seafarers in the British merchant fleet (1986-1995) and recommendations for their reduction. *Occup Med (Chic Ill)*. 2002;52:195-202. doi:10.1093/occmed/52.4.195
10. Berg HP. Human Factors and Safety Culture in Maritime Safety (revised). *Mar Navig Saf Sea Transp STCW, Marit Educ Train (MET), Hum Resour Crew Manning, Marit Policy, Logist Econ Matters*. 2013;7(3):107-115. doi:10.12716/1001.07.03.04
11. Carter T. Mapping the knowledge base for maritime health: 1 historical perspective.

- 1
2
3 *Int Marit Health*. 2011;62(4):210-216.
4
5
6 12. Carter T. Mapping the knowledge base for maritime health: 2. a framework for
7 analysis. *Int Marit Health*. 2011;62(4):217-223. Accessed October 12, 2019.
8 <http://www.ncbi.nlm.nih.gov/pubmed/22544496>
9
10
11 13. Carter T. Mapping the knowledge base for maritime health: 3 illness and injury in
12 seafarers. *Int Marit Health*. 2011;62(4):224-240.
13
14
15 14. Carter T. Mapping the knowledge base for maritime health: 4 safety and performance
16 at sea. *Int Marit Health*. 2011;62(4):236-244. Accessed October 12, 2019.
17 <http://www.ncbi.nlm.nih.gov/pubmed/22544498>
18
19
20 15. Lefkowitz RY, Slade MD, Redlich CA. "Injury, illness, and work restriction in merchant
21 seafarers." *Am J Ind Med*. 2015;58(6):688-696. doi:10.1002/ajim.22459
22
23
24 16. Hannerz H. Hospitalisations among seafarers on merchant ships. *Occup Env Med*.
25 2005;62:145-150. doi:10.1136/oem.2004.014779
26
27
28 17. Kaerlev L, Jensen A, Nielsen PS, Olsen J, Hannerz H, Tüchsen F. Hospital contacts for
29 injuries and musculoskeletal diseases among seamen and fishermen : A population-
30 based cohort study. *BioMed Cent*. 2008;9:1-9. doi:10.1186/1471-2474-9-8
31
32
33 18. Herttua K, Gerdøe S, Vork JC, Nielsen JB. Age and nationality in relation to injuries
34 at sea among officers and non- - officers : a study based on contacts from ships to
35 Telemedical Assistance Service in Denmark. *BMJ Open*. 2019;9:1-7.
36 doi:10.1136/bmjopen-2019-034502
37
38
39
40 19. Oldenburg M, Jensen HJ. Stress and strain among seafarers related to the
41 occupational groups. *Int J Environ Res Public Health*. 2019;16(7).
42 doi:10.3390/ijerph16071153
43
44
45 20. Oldenburg M, Jensen HJ, Latza U, Baur X. Seafaring stressors aboard merchant and
46 passenger ships. *Int J Public Health*. 2009;54(2):96-105. doi:10.1007/s00038-009-
47 7067-z
48
49
50
51 21. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication
52 in providing maritime medical assistance. *Int Marit Health*. 2016;67(4):187-195.
53 doi:10.5603/imh.2016.0036
54
55
56
57
58
59
60

- 1
 - 2
 - 3
 - 4
 - 5
 - 6
 - 7
 - 8
 - 9
 - 10
 - 11
 - 12
 - 13
 - 14
 - 15
 - 16
 - 17
 - 18
 - 19
 - 20
 - 21
 - 22
 - 23
 - 24
 - 25
 - 26
 - 27
 - 28
 - 29
 - 30
 - 31
 - 32
 - 33
 - 34
 - 35
 - 36
 - 37
 - 38
 - 39
 - 40
 - 41
 - 42
 - 43
 - 44
 - 45
 - 46
 - 47
 - 48
 - 49
 - 50
 - 51
 - 52
 - 53
 - 54
 - 55
 - 56
 - 57
 - 58
 - 59
 - 60
22. Ehara M, Muramatsu S, Sano Y, Takeda S, Hisamune S. The tendency of diseases among seamen during the last fifteen years in Japan. *Ind Health*. 2006;44(1):155-160. doi:10.2486/indhealth.44.155
23. STCW. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers. IMO. Published 1995. Accessed May 2, 2020. <http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx>
24. Leino P. Symptoms of stress predict musculoskeletal disorders. *J Epidemiol Community Health*. 1989;43(3):293-300. doi:10.1136/jech.43.3.293
25. Lim SK, Yoo SJ, Koo DL, et al. Stress and sleep quality in doctors working on-call shifts are associated with functional gastrointestinal disorders. *World J Gastroenterol*. 2017;23(18):3330-3337. doi:10.3748/wjg.v23.i18.3330
26. Caruso G. "Do seafarers have sunshine." 8th International Symposium on Maritime Health (ISMH) Book of abstracts. Published online 2005.
27. Laraqui O, Manar N, Laraqui S, et al. Prevalence of skin diseases amongst Moroccan fishermen. *Int Marit Health*. 2018;69(1):22-27. doi:10.5603/IMH.2018.0004
28. Meyer G, Siekmann H, Feister U, Felten C HJ. Measurement of sunlight exposure in seafaring [Ermittlung der natürlichen UV-Strahlenexposition in der Seeschifffahrt]. 50. Jahrestagung der Deutschen Gesellschaft für Arbeitsmedizin und Umweltmedizin (DGAUM). *Eur J Dermatol*. Published online 2010:434-436.
29. Oldenburg M, Kuechmeister B, Ohnemus U, Baur X, Moll I. Extrinsic skin ageing symptoms in seafarers subject to high work-related exposure to UV radiation. *Eur J Dermatology*. 2013;23(5):663-670. doi:10.1684/ejd.2013.2142
30. Nittari G, Tomassoni D, Di Canio M, et al. Overweight among seafarers working on board merchant ships. *BMC Public Health*. 2019;19(1):1-8. doi:10.1186/s12889-018-6377-6
31. Kivimäki M, Kawachi I. Work Stress as a Risk Factor for Cardiovascular Disease. *Curr Cardiol Rep*. 2015;17(9). doi:10.1007/s11886-015-0630-8
32. Virtanen M, Heikkilä K, Jokela M, et al. Long working hours and coronary heart disease: A systematic review and meta-analysis. *Am J Epidemiol*. 2012;176(7):586-

- 1
2
3 596. doi:10.1093/aje/kws139
4
5
6 33. Shin K, Chung Y, Kwon ÆY. The Effect of Long Working Hours on Cerebrovascular and
7 Cardiovascular Disease ; A Case-Crossover Study. 2017;761(December 2016):753-
8 761. doi:10.1002/ajim.22688.
9
10
11 34. Boivin DB, Boudreau P. Impacts of shift work on sleep and circadian rhythms. *Pathol*
12 *Biol.* 2014;62(5):292-301. doi:10.1016/j.patbio.2014.08.001
13
14
15 35. Hermansson J, Hallqvist J, Karlsson B, Knutsson A, Gådin KG. Shift work, parental
16 cardiovascular disease and myocardial infarction in males. *Occup Med (Chic Ill)*.
17 2018;68(2):120-125. doi:10.1093/occmed/kqy008
18
19
20 36. Steptoe A, Kivimäki M. Stress and cardiovascular disease. *Nat Rev Cardiol*.
21 2012;9(6):360-370. doi:10.1038/nrcardio.2012.45
22
23
24 37. Li J, Zhang M, Loerbroks A, Angerer P, Siegrist J. Work stress and the risk of
25 recurrent coronary heart disease events: A systematic review and meta-analysis. *Int*
26 *J Occup Med Environ Health*. 2015;28(1):8-19. doi:10.2478/s13382-014-0303-7
27
28
29 38. Dragano N, Siegrist J, Nyberg ST, et al. Effort-Reward Imbalance at Work and
30 Incident Coronary Heart Disease: A Multicohort Study of 90,164 Individuals.
31 *Epidemiology*. 2017;28(4):619-626. doi:10.1097/EDE.0000000000000666
32
33
34
35 39. Sara JD, Prasad M, Eleid MF, Zhang M, Jay Widmer R, Lerman A. Association between
36 work-related stress and coronary heart disease: A review of prospective studies
37 through the job strain, effort-reward balance, and organizational justice models. *J Am*
38 *Heart Assoc*. 2018;7(9):1-15. doi:10.1161/JAHA.117.008073
39
40
41
42 40. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work
43 stress in the etiology of coronary heart disease - A meta-analysis. *Scand J Work*
44 *Environ Heal*. 2006;32(6):431-442. doi:10.5271/sjweh.1049
45
46
47 41. Jaremin B KE. Myocardial infarction (MI) at the work-site among Polish seafarers. The
48 risk and the impact of occupational factors. *Int Marit Heal*. 2003;54(1-4):26-39.
49
50
51 42. Filikowski J, Rzepliak M, Renke W, Winnicka A SD. Selected risk factors of ischemic
52 heart disease in Polish seafarers. Preliminary report. *Int Marit Heal*. 2003;54(1-4):40-
53 46.
54
55
56
57
58
59
60

- 1
2
3 43. Siegrist J, Rodel A. Work stress and health risk behavior. *Scand J Work Env Heal*.
4 2006;32(6):473-481. doi:10.5271/sjweh.1052
5
6
7 44. Jensen OC, Sørensen JF, Canals ML, Hu YP, Nikolic N TM. Incidence of self-reported
8 occupational injuries in seafaring — an international study. *Occup Med*.
9 2004;54(8):548-555. doi:10.1093/occmed/kqh090
10
11
12 45. Harrington JM. Health effects of shift work and extended hours of work. *Occup*
13 *Environ Med*. 2001;58(1):68-72.
14
15
16 46. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with
17 long working hours: A review of the current position. *Occup Environ Med*.
18 1997;54(6):367-375. doi:10.1136/oem.54.6.367
19
20
21
22
23
24
25

Legends of the figures

26
27
28 Figure 1. Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n =
29 338)
30
31

32 Figure 2: Distribution of injured body parts of seafarers with injuries from 2016 to
33 2019 (n = 85)
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

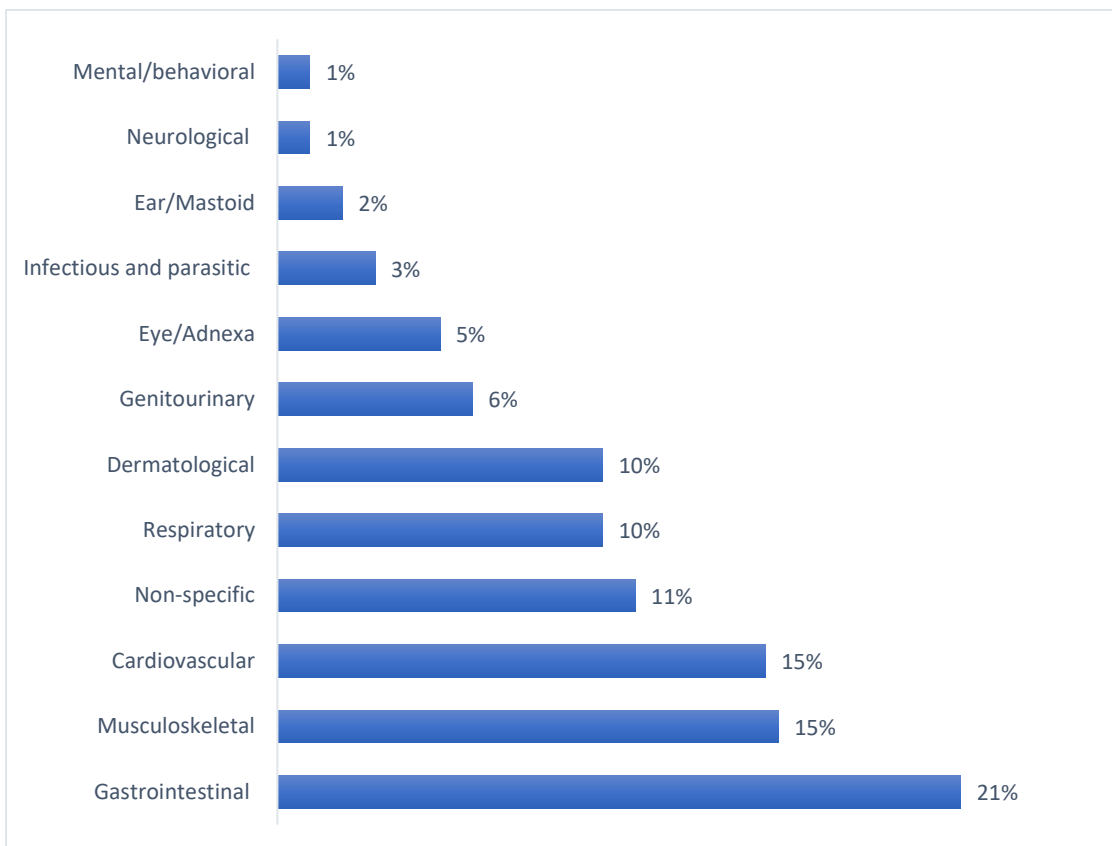


Figure 1

view only

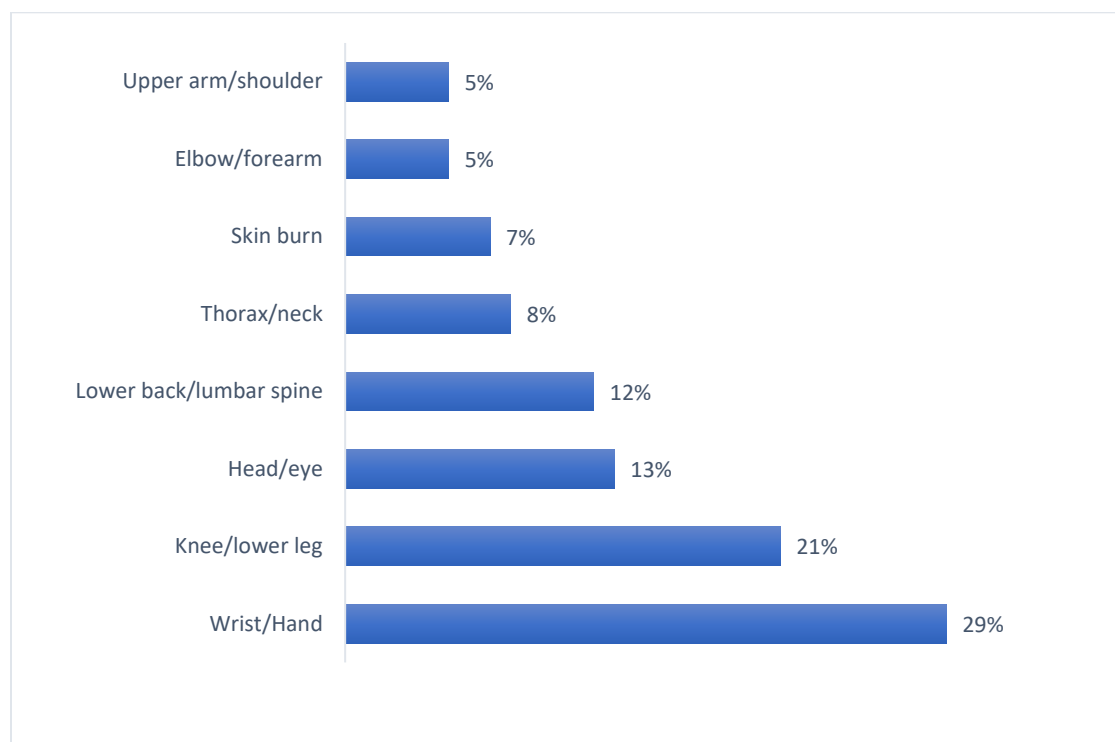


Figure 2

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 (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	5&6 6
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 (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	7, 8, 9,11 & 13
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.