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

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To cite: Sagaro GG, Dicanio M, Battineni G, *et al*. 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. *BMJ Open* 2021;**11**:e044633. doi:10.1136/bmjopen-2020-044633

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-044633).

Received 08 September 2020
Revised 17 February 2021
Accepted 18 February 2021

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ABSTRACT

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

Design Descriptive epidemiological study.

Setting and participants This study's data were based on contacts (n=423) for medical requests from Compagnie Maritime d'Affrètement/Compagnie Générale Maritime (CMA-CGM) container ships to the Italian Telemedical Maritime Assistance Service 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% CI.

Results The total disease rate was 25 per 1000 seafarer-years, and the overall injury rate was 6.31 per 1000 seafarer-years over the 4 years study period. Non-officers were more likely than officers to have reported gastrointestinal (IRR 2.12, 95% CI 1.13 to 4.26), dermatological (IRR 3.66, 95% CI 1.27 to 14.42) and musculoskeletal (IRR 2.25, 95% CI 1.11 to 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 to 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.

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 Telemedical Maritime Assistance Service.
- ► The estimated at-risk seafarer population was used in the analysis due to the lack of information on the actual at-risk seafarer population.

INTRODUCTION

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

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

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

The exposure to the work-related risk of officers and non-officers working in different ship areas such as deck, engine and galley is not similar because they attend different duties in different working hours.[19] For instance, workers in the engine room are exposed to work-related risks such as noise, vibration and heat or pollutants during their working hours.[19 20] In contrast, people working in the deck, as well as in the galley, are potentially exposed to different work-related risks.[19] Because of the different areas of activity and associated burdens, the likelihood of illnesses and the occurrence of injuries can differ. Hence, the study on the incidence rates (IR) of injury and disease by rank and worksite of seafarers would provide information for prevention strategies such as resource allocation, prioritising training areas, improving the medicine chests on board, and access to telemedicine consultation to reduce injury and disease at the workplace.

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

MATERIALS AND METHODS

Study design, data source and collection procedure

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

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

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

An estimated total number of at-risk seafarer population was calculated by multiplying the number of vessels during the study period by the average number of crew members per vessel. As a result, large ships, including general cargo, tankers and bulk carriers, have an average size of 20 crew members per ship.[3] The CMA CGM shipping company handles only container ships, with an average of 25 crew members per ship. Regarding rank distribution per ship, nine officers and sixteen non-officers serve onboard. In respect of worksite, 10 deck workers, thirteen engine workers and two galleys (catering) workers are in service per vessel. The average number of the crew size, their rank as well as worksite distribution per large vessel based on the knowledge of industry norm were calculated.

The number of CMA CGM container ships contracted over 4 years, from January 2016 to 31 December 2019, was 539. In other words, 539 vessels represented the total number of active ships onboard in 4 years (January

2016 to 31 December 2019), and due to this, we determined the cumulative IR. An estimated number of the total at-risk seafarer population for worksite and rank was determined by multiplying the total number of vessels over 4 years by occupation and rank distribution per ship. The total number of seafarers at risk was adjusted proportionally to the number of seafarers in the dataset for whom information on occupation and rank was available.

Statistical analysis

Descriptive statistics such as mean and SD of age, frequency and percentage of injuries by anatomic location and types of diseases were done to evaluate the distribution of reported occupational injuries and diseases in seafarers with injuries and diseases. Rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley). The worksite was also categorised into three groups, including the deck, engine and galley. Then, worksite and rank-specific IR were calculated by dividing the number of cases by the total at-risk seafarer population for each worksite and rank over 4 years. IR ratio (IRR) and 95% CI were calculated to compare the injuries and diseases rates by seafarer's rank and worksite. The outcome of rates was expressed as per 1000 seafarer-years. Seafarer-year is defined as the number of crew members per ship multiplied by the number of vessels each year. The χ^2 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 V.15 was used for data analysis.

Patient and public involvement

Patients and public were not involved in the study.

RESULTS

Overall, 423 patients were assisted by the C.I.R.M. aboard container ships during the 4-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 two times more likely than engine workers to be injured (p<0.004) (table 1).

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

Table 1 Number of cases, seafarer-years, incidence rates and incidence rate ratios (IRR) 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 to 7.86)	N/A	
Rank					
Officer	19	4451	4.27 (2.57 to 6.66)	1	
Non-officer	59	7914	7.45 (5.68 to 9.61)	**1.75** (1.02 to 3.10)	0.029
Worksite					
Deck	43	4946	8.69 (6.29 to 11.69)	**1.99** (1.21 to 3.34)	0.004
Engine	28	6430	4.35 (2.89 to 6.29)	1	
Galley	7	989	7.07 (2.85 to 14.53)		
	Disease (n=301)	**Seafarer-years**	**Disease incidence rate (95% CI)**	**IRR* (95% CI)**	
Total	301	12 000	25.00 (22.36 to 28.04)	N/A	
Rank					
Officer	84	4320	19.44 (15.54 to 24.02)	1	
Non-officer	217	7680	28.25 (24.66 to 32.21)	**1.45** (1.12 to 1.89)	0.003
Worksite					
Deck	171	4800	35.63 (30.56 to 41.26)	**2.12** (1.65 to 2.72)	0.001
Engine	105	6240	16.83 (13.78 to 20.33)	1	
Galley	25	960	26.00 (16.92 to 38.20)		

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

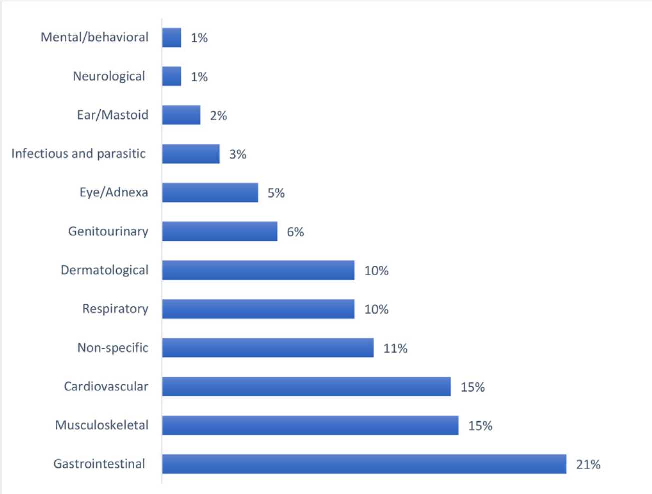

Figure 1 Diagnosis of seafarers according to WHO ICD 10th category from 2016 to 2019 (n=338). ICD-10, International Classification of Disease 10th revised version.

leg injuries, 13% were head/eye injuries, 12% were lower back/lumbar spine injuries, 8% were thorax/neck injuries (figure 2).

Rank-specific IR 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 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).

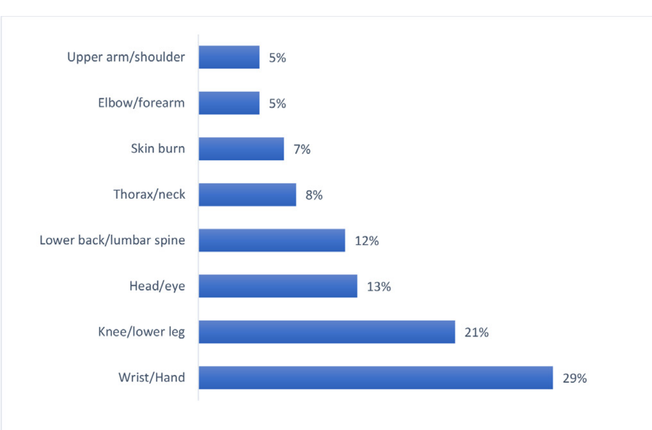

Figure 2 Distribution of injured body parts of seafarers with injuries from 2016 to 2019 (n=85).

Worksite-specific IR of diseases and occupational injuries

Table 3 summarises 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).

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

DISCUSSION

This descriptive epidemiological study was mainly designed to quantify the IR of reported injuries and diseases among seafarers by worksite and rank groups. We have found that the rates of overall reported diseases were four times higher than the corresponding total reported injuries rates across all worksites. A similar finding was reported from a study conducted in the USA,[15] which reported 2–3 times total illnesses higher in the worksites than overall injuries. The overall reported disease rate was 25 per 1000 seafarer-year during the study period. The disease rate for non-officers and officers were significantly differed (IRR 1.45, 95% CI 1.12 to 1.89). This study reported that the most common causes of illnesses on board were gastrointestinal (21%), musculoskeletal (15%) and cardiovascular disorders (15%). Similar findings were reported in a Japanese study,[22] which has shown that gastrointestinal (35.5%), musculoskeletal (19.6%) and cardiovascular diseases (11.6%) were the diseases more often occurring onboard ships. Our findings are not consistent with the study conducted in the USA,[3] which reported that dental (26%), respiratory (19%), and dermatological (14%) disorders were in the order the illnesses occurring most often among sailing seafarers.

The majority of gastrointestinal (63%) cases were gastro-oesophageal reflux, oesophagitis, 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

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

*IRR calculated as the rate of non-officer/rate of officer.
†Significant at *p<0.05.
‡Dashes indicate no case or the rate or the comparison that was not performed.
IRR, incidence rate ratio; N/A, not applicable.

such as navigation, planning, organisation 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 with ashore workers[20] because their work is characterised by long working hours, often time-pressure, prolonged isolation from family and hectic activity. Various studies have reported that work-related stress has long been considered a contributing factor in the development of musculoskeletal problems[24] and gastrointestinal disorders.[25] Similarly, as for dermatological disorders, it might result in skin exposure to risk factors in the workplace. Seafaring is a risky activity characterised by exposure to different skin risk factors such as seawater, humidity, solar radiation and others.[26 27] Deck crews are frequently engaged in maintenance, repair, loading, painting activities and exposure to chemicals, UV radiation and other skin risk factors.[28 29] This study also reported the same rate of dermatological disorders for the deck (IR=3.96) and galley (IR=3.96) workers. However, this could be due to the small number of cases among galley workers, and even the estimated non-cases of galley workers are not comparable in number to deck workers' non-cases. Consequently, 95% of the CI was wider for the case rate among the galley workers. The IRR results in the comparison made between the workers on deck and in the galley were also not statistically significant (p=1.044) on this matter. Further studies are needed to measure the effect of differences in the workplace of deck and galley workers on dermatological disease rates.

Angina pectoris (39% of all CVD diagnoses) was the most frequently reported cardiovascular disorders in this study. As for cardiovascular disorders, it could be related to lifestyle, especially a high-fat diet, drinking, smoking and physical inactivity. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight and obese, respectively.[30] This finding suggests that in seafarer's CVD risk factors are higher compared with ashore workers. We found that cardiovascular (IR=6.06) disorders were the second most common diseases for deck workers and deck workers were also more likely than engine worker to have reported cardiovascular diseases (IRR=3.26). This might

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

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

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

be due to work-related stress because deck workers have high work-related stress due to sleep interruption, high job demands, night shift work and intense activity than engine workers. A study reported that work related stress was a risk factor for cardiovascular diseases.[31] Long working hours are contributing factors to work-related stress, and it is logical to expect an association between long hours and cardiovascular disorders.[32 33] Studies have also shown that night shift work had adverse effects on health and risk factors for the development of chronic diseases such as cardiovascular diseases.[19 34 35] The relationship between stress and coronary heart disease are considered to be linked to multiple and protracted increases in heart rate and blood pressure resulting from neuroendocrine activation.[36–39] Other studies have reported that work-related stress can increase the cardiovascular risk of workers.[40–42] On the other hand, cardiovascular diseases and metabolic disorders are stress-related diseases.[43]

The total reported injury rate was 6.31 per 1000 seafarer-year over 4 years study period. The injury rate for non-officers and officers were significantly differed (IRR 1.75, 95% CI 1.02 to 3.10). Nearly 30% of injuries occurred in the wrist and hand, followed by the knee and lower leg (21%). Our results agree with the study conducted in the Danish-flagged merchant fleet,[18] which reported 36% and 18% of upper and lower limb injuries, respectively. Moreover, this study revealed that non-officers were more likely than officers to be injured (IRR=1.75). This finding was in agreement with the previous studies.[3 17 44] Non-officer work is characterised by mooring, cleaning the ship, repairing broken cables and ropes, operating machinery such as cranes and drilling towers, and steering the ship at sea.[20 23] The non-officer work is also physically challenging[19 20 23] and must be carried out regardless of weather conditions. This could explain why non-officers have a higher rate of injuries than officers.

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

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

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

*Significant at p<0.05.
†Dashes indicate the comparison that was not performed.
N/A, not applicable.

methodological differences. The study on seafarers in the Danish fleet was a questionnaire-based survey. Furthermore, denominators, used to determine IR and IRR in the Danish fleet, were not consistent with our study. Deck workers, particularly deck ratings, perform physical works such as mooring and unmooring the ship, loading, and unloading cargo.[23] Moreover, deck workers have a shorter sleeping time and sleep interruptions more often than engine workers because they are engaged in the surveillance system with frequent irregular operations. These include monitoring the bridge or gangway, acting as lookouts on the bridge, or carrying out repairs and maintenance work in the deck area.[19 20 23] Hence, night shift work, long working hours, short average sleep time and physical stress are important factors contributing to the high rates of injuries/accidents at sea.[10 19 45 46]

Strengths and limitations

This study measured the IR of reported injury and disease to TMAS for container ships. Most of the previous studies on diseases and injuries among seafarers were focused on the number of cases. As far as we know, this study is the first study to measure the contribution of differences in rank and job to the rates of injury and disease of seafarers onboard container ships. Limitations of this study are: (1) We used an estimated average number of seafarers per ship in the analysis, although we took into account different assumptions, including the number of vessels, ships active at sea, number of crew members per ship and the length of stay of seafarers on board for the accuracy of the estimate. Consequently, the IR 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 IRR of the diseases and injuries by seafarers' age and sex. (3) Patient data on both injury and diagnosis were compiled according to the revised WHO ICD10 codes and the injury's anatomic location in the database, but not on mechanisms of injury or potential physical hazards related to injured cases. As a result, we have not stratified injuries by mechanisms of injury or occupational hazards to highlight priority areas and recommend preventative measures. (4) We did not have descriptions of data types such as socio-demographic variables and another exposure status of the total seafarer population at risk. In this respect, we have not determined the risk factors for injury and disease to propose further prevention strategies. Furthermore, this study is a retrospective study and limited to the variables available in the dataset. Finally, our study is limited to container ships and does not represent other types of ships at sea. Hence, the results do not reflect seafarers working on other types of ships.

CONCLUSION

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

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

Competing interests None declared.

Patient consent for publication Not required.

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

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

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REFERENCES

1. BIMCO, ICS. "Manpower Report-The global supply and demand for seafarers, 2015Exec Summ. Available: 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. Available: https://www.ship-technology.com/features/featuretelemedicine-revolutionising-healthcare-for-seafarers-5673476/ [Accessed 10 Aug 2019].
3. Lefkowitz RY, Slade MD, Redlich CA. Injury, illness, and disability risk in American seafarers. *Am J Ind Med* 2018;61:120–9.
4. IMO (International Maritime Organization). Available: https://business.un.org/en/entities/13 [Accessed 12 Oct 2019].
5. Center for maritime safety and health studies, 2019. Available: https://www.cdc.gov/niosh/programs/cmshs/port_operations.html [Accessed 12 Oct 2019].
6. Mulić R, Vidan P. Comparative analysis of medical assistance to seafarers in the world and the Republic of Croatia. *Int Conf Transp Sci* 2012:1–8 https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf
7. Roberts SE, Nielsen D, Kotłowski A, *et al*. Fatal accidents and injuries among Merchant seafarers worldwide. *Occup Med* 2014;64:259–66.
8. Borch DF, Hansen HL, Burr H, *et al*. Surveillance of maritime deaths on board Danish merchant ships, 1986-2009. *Int Marit Health* 2012;63:7–16.
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* 2002;52:195–202.
10. Berg HP. Human factors and safety culture in maritime safety (revised). *TransNav* 2013;7:343–52.
11. Carter T. Mapping the knowledge base for maritime health: 1 historical perspective. *Int Marit Health* 2011;62:210–6.
12. Carter T. Mapping the knowledge base for maritime health: 2. a framework for analysis. *Int Marit Health* 2011;62:217–23.
13. Carter T. Mapping the knowledge base for maritime health: 3 illness and injury in seafarers. *Int Marit Health* 2011;62:224–40.
14. Carter T. Mapping the knowledge base for maritime health: 4 safety and performance at sea. *Int Marit Health* 2011;62:236–44.
15. Lefkowitz RY, Slade MD, Redlich CA. "Injury, illness, and work restriction in merchant seafarers". *Am J Ind Med* 2015;58:688–96.
16. Hansen HL, Tüchsen F, Hannerz H. Hospitalisations among seafarers on merchant ships. *Occup Environ Med* 2005;62:145–50.
17. Kaerlev L, Jensen A, Nielsen PS, *et al*. Hospital contacts for injuries and musculoskeletal diseases among seamen and fishermen: a population-based cohort study. *BMC Musculoskelet Disord* 2008;9:1–9.
18. Herttua K, Gerdøe-Kristensen S, Vork JC, *et al*. Age and nationality in relation to injuries at sea among officers and non-officers: a study based on contacts from ships to telemedical assistance service in Denmark. *BMJ Open* 2019;9:e034502–7.
19. Oldenburg M, Jensen H-J. Stress and strain among Seafarers related to the occupational groups. *Int J Environ Res Public Health* 2019;16:1153.
20. Oldenburg M, Jensen H-J, Latza U, *et al*. Seafaring stressors aboard merchant and passenger ships. *Int J Public Health* 2009;54:96–105.
21. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication in providing maritime medical assistance. *Int Marit Health* 2016;67:187–95.
22. Ehara M, Muramatsu S, Sano Y, *et al*. The tendency of diseases among seamen during the last fifteen years in Japan. *Ind Health* 2006;44:155–60.
23. STCW, IMO. International convention on standards of training, certification and Watchkeeping for Seafarers. Available: 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;43:293–300.
25. Lim S-K, 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;23:3330–7.

26 Caruso G. Do seafarers have sunshine. *8th International Symposium on Maritime Health (ISMH) Book of abstracts*, 2005.
27 Laraqui O, Manar N, Laraqui S, *et al*. Prevalence of skin diseases amongst Moroccan fishermen. *Int Marit Health* 2018;69:22–7.
28 Meyer G, Siekmann H, Feister U. Measurement of sunlight exposure in seafaring [determination of natural UV radiation exposure in seafaring]. *50th annual meeting of the German Society for Occupational and Environmental Medicine (DGAUM)*, 2010:434–6.
29 Oldenburg M, Kuechmeister B, Ohnemus U, *et al*. Extrinsic skin ageing symptoms in seafarers subject to high work-related exposure to UV radiation. *Eur J Dermatol* 2013;23:663–70.
30 Nittari G, Tomassoni D, Di Canio M, *et al*. Overweight among seafarers working on board merchant ships. *BMC Public Health* 2019;19:1–8.
31 Kivimäki M, Kawachi I. Work stress as a risk factor for cardiovascular disease. *Curr Cardiol Rep* 2015;17:630.
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;176:586–96.
33 Shin K-S, Chung YK, Kwon Y-J, *et al*. The effect of long working hours on cerebrovascular and cardiovascular disease; a case-crossover study. *Am J Ind Med* 2017;60:753–61.
34 Boivin DB, Boudreau P. Impacts of shift work on sleep and circadian rhythms. *Pathol Biol* 2014;62:292–301.
35 Hermansson J, Hallqvist J, Karlsson B, *et al*. Shift work, parental cardiovascular disease and myocardial infarction in males. *Occup Med* 2018;68:120–5.
36 Steptoe A, Kivimäki M. Stress and cardiovascular disease. *Nat Rev Cardiol* 2012;9:360–70.
37 Li J, Zhang M, Loerbroks A, *et al*. Work stress and the risk of recurrent coronary heart disease events: a systematic review and meta-analysis. *Int J Occup Med Environ Health* 2015;28:8–19.
38 Dragano N, Siegrist J, Nyberg ST, *et al*. Effort-Reward imbalance at work and incident coronary heart disease: a Multicohort study of 90,164 individuals. *Epidemiology* 2017;28:619–26.
39 Sara JD, Prasad M, Eleid MF, *et al*. Association between work-related stress and coronary heart disease: a review of prospective studies through the job strain, effort-reward balance, and organizational justice models. *J Am Heart Assoc* 2018;7:1–15.
40 Kivimäki M, Virtanen M, Elovainio M, *et al*. Work stress in the etiology of coronary heart disease--a meta-analysis. *Scand J Work Environ Health* 2006;32:431–42.
41 Jaremin B, Kotulak E. Myocardial infarction (MI) at the work-site among Polish seafarers. the risk and the impact of occupational factors. *Int Marit Health* 2003;54:26–39.
42 Filikowski J, Rzepiak M, Renke W, *et al*. Selected risk factors of ischemic heart disease in Polish seafarers. preliminary report. *Int Marit Health* 2003;54:40–6.
43 Siegrist J, Rödel A. Work stress and health risk behavior. *Scand J Work Environ Health* 2006;32:473–81.
44 Jensen OC, Sørensen JF, Canals ML. Incidence of self-reported occupational injuries in seafaring — an international study. *Occup Med* 2004;54:548–55.
45 Harrington JM. Health effects of shift work and extended hours of work. *Occup Environ Med* 2001;58:68–72.
46 Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with long working hours: a review of the current position. *Occup Environ Med* 1997;54:367–75.

Journal of *Personalized Medicine*

Article

Self-Reported Modifiable Risk Factors of Cardiovascular Disease among Seafarers: A Cross-Sectional Study of Prevalence and Clustering

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Abstract: Background: Cardiovascular diseases (CVD) are the major cause of work-related mortality from diseases onboard ships in seafarers. CVD burden derives mainly from modifiable risk factors. To reduce the risk factors and the burden of CVD onboard ships in seafarers, it is important to understand the up-to-date prevalence of modifiable risk factors. The primary purpose of this study was to assess the prevalence and clustering of self-reported modifiable CVD risk factors among seafarers. We have also explored the association between socio-demographic and occupational characteristics and reported modifiable CVD risk factor clustering. Materials and methods: A cross-sectional study was conducted among seafarers from November to December 2020 on board ships. In total, 8125 seafarers aged 18 to 70 were selected from 400 ships. Data were collected using a standardized and anonymous self-reported questionnaire. The prevalence value for categorical variables and mean differences for continuous variables were compared using chi-square and independent sample t-tests. Multinomial logistic regression models were performed to identify independent predictors for modifiable CVD risk factor clustering. Results: Out of a total of 8125 seafarers aged ≥18 years on selected vessels, 4648 seafarers volunteered to participate in the survey, with a response rate of 57.2%. Out of 4318 participants included in analysis, 44.7% and 55.3% were officers and non-officers, respectively. The prevalence of reported hypertension, diabetes, current smoking and overweight or obesity were 20.8%, 8.5%, 32.5%, and 44.7%, respectively. Overall, 40%, 20.9%, 6% and 1.3% of the study participants respectively had one, two, three and four modifiable CVD risk factors. Older age (51+ years) (odds ratio (OR): 3.92, 95% confidence interval (CI): 2.44–6.29), being non-officers (OR: 1.36, 95% CI: 1.09–1.70), job duration (10–20 years) (OR: 2.73, 95% CI: 2.09–3.57), job duration (21+ years) (OR: 2.60, 95% CI: 1.79–3.78), working 57–70 h per week (OR: 2.03, 95% CI: 1.65–2.49) and working 71+ h per week (OR: 3.08, 95% CI: 2.42–3.92) were independent predictors for at least two self-reported modifiable CVD risk factor clustering. Conclusion: The results of our study demonstrate that more than four in six (68.5%) seafarers aged between 19 and 70 years have at least one of the modifiable CVD risk factors. Therefore, CVD prevention and modifiable risk factors reduction strategies targeting high-risk groups should be designed and implemented on board ships.

Keywords: seafarers; hypertension; cardiovascular disease; occupation; diabetes; body mass index; cigarette smoking; modifiable risk factors

Citation: Sagaro, G.G.; Battineni, G.; Di Canio, M.; Amenta, F. Self-Reported Modifiable Risk Factors of Cardiovascular Disease among Seafarers: A Cross-Sectional Study of Prevalence and Clustering. *J. Pers. Med.* **2021**, *11*, 512. https://doi.org/10.3390/jpm11060512

Academic Editor: Konstantinos Tziomalos

Received: 10 April 2021
Accepted: 31 May 2021
Published: 4 June 2021

1. Introduction

Globally, cardiovascular diseases (CVD) are the leading causes of mortality and disability [1]. The prevalence of overall CVD increased from 271 million in 1990 to 523 million in 2019, and mortality due to CVD also increased from 12.1 million to 18.6 million respectively from 1990 to 2019 worldwide [1]. CVD are responsible for approximately 31% (17.9

million) of all death worldwide, and four out of five (80%) deaths from these diseases were due to heart attacks and strokes [2].

CVDs are also the major cause of work-related mortality from diseases among seafarers' onboard ships. A study conducted on British merchant shipping reported that 4601 (19.8%) of 23,291 work-related deaths from 1919 to 2005 were due to CVD [3]. Another study found that 147 (38.4%) out of the 384 documented deaths at sea were from CVDs [4]. Various studies have reported that a high percentage of deaths among seafarers was due to CVDs in Polish vessels (62 (19%) of 324 deaths) [5], on Danish merchant ships (35 (66%) of 53 deaths) [6], on Singapore ships (45 (65%) of 69 deaths) [7], and in Isle of Man shipping (16 (80%) of 20 deaths) [8]. In terms of morbidity, CVDs are among the top five (gastrointestinal, CV, musculoskeletal, dermatological and respiratory disorders) major cause of illness from diseases at sea among seafarers [9–12].

CVD burden attributable to modifiable risk factors, namely hypertension, diabetes, overweight or obesity, high low-density lipoprotein cholesterol, and cigarette smoking, was increased worldwide [1]. For instance, globally, 5.02 million death and 160 million disability-adjusted life years (DALYs) were attributed to high BMI in 2019. Further, the number of deaths caused by diabetes and high blood pressure increased respectively from 2.91 million and 6.79 million in 1990 to 6.50 million and 10.8 million in 2019 [1]. Different studies conducted in the general population [13–15] and seafarers [16–20] were reported that modifiable CVD risk factors included cigarette smoking, overweight or obesity, hypertension, and diabetes, can be reduced or eliminated by modifying lifestyle behaviors. Studies found that the prevalence of CVD risk factors included overweight or obesity and cigarette smoking to be higher among seafarers when compared to the general population [21,22]. There are different reasons that seafarers might have more modifiable CVD risk factors compared to the general population. Their work is both physically and psychologically stressful, working long hours and short average sleep time, prolonged time away from their family. It has been also demonstrated that work-related stress is a main contributor to CVD risk factors [21,23].

To mitigate the risk factors and the burden of CVD onboard ships among seafarers, it is important to understand the up-to-date prevalence of modifiable risk factors. Analysis of which modifiable risk factors frequently occur simultaneously is relevant for identifying a high-risk group. Understanding how clustering of CVD risk factors is associated with socio-demographic and occupational characteristics could help for developing effective CVD prevention and control strategies.

The present study has investigated the prevalence of reported modifiable CVD risk factors and their distribution by socio-demographic and occupational characteristics among seafarers. We have also investigated the association between socio-demographic and occupational variables and reported modifiable CVD risk factor clustering among seafarers. This study is probably the first investigation involving a large representative sample of seafarers, and no study has been conducted so far on reported modifiable CVD risk factors and clustering among seafarers. The present work could therefore provide up-to-date, evidence-based information on the prevalence and clustering of modifiable CVD risk factors in seafarers.

2. Materials and Methods

2.1. Study Design and Setting

In the present study, we conducted a cross-sectional epidemiological study to assess the prevalence and clustering of reported modifiable CVD risk factors among seafarers. This study was conducted from November to December 2020 onboard ships. Currently, nearly 65,000 deep-sea merchant ships operate, carrying an average of 1.3 million seafarers worldwide [24]. The workforce onboard ship is classified into three broad categories: deck, engine, and galley/support personnel. In 2015, the number of seafarers actively employed at sea, 774,000 officers, and 873,500 ratings (non-officers) [24].

2.2. Study Participants and Procedures

The study participants were recruited through International Radio Medical Center (C.I.R.M.). C.I.R.M. is an Italian Telemedical Maritime Assistance Service (TMAS) Center and is the organization with the largest experience worldwide in terms of the number of patients assisted onboard ships. C.I.R.M. provides teleconsultations and medical advice to seafarers and passengers regardless of their nationality and flag of the vessels 24 h a day, seven days a week, and 365/366 days a year. C.I.R.M. has more than 5000 ship contacts. Of these, 400 ships were selected randomly from the ships' list by applying a simple random sampling strategy. In the second step, the research team presented the study's purpose and protocol to all captains of selected vessels to obtain permission to submit a self-reported anonymous questionnaire and requested the list of seafarers per ship. The captains of 400 ships agreed to participate in the study and provided the active seafarers' (seafarers on duty) lists per vessel. A list of a total of 8125 seafarers with indication of their names, age and ranking was obtained in a sample of 400 ships. Inclusion criteria were seafarers over the age of 18 and signing the informed consent form. In the subsequent step, a simple random sampling method to select the potential participants from the list based on our eligibility criteria was used.

All crew members were eligible for this study because they are greater than 18 years old. According to the International Labor Organization (ILO), seafarers' recruitment policy limits seafarers' age, and anyone who is recruited as a seafarer must be over 18 years of age [25]. As for the data collection, the research team collaborated with the C.I.R.M. doctors and provided one-day training via videoconferencing for the telemedicine case manager and one crew member per ship on survey administration and how to measure the body weight and height of the participating crew members. Telemedicine Case Managers (TCMs) are already trained medical first responders and have experience working with seafarers' aboard ships and TMAS doctors or other health professionals. As a result, the questionnaire was sent to telemedicine case managers via their email address by the C.I.R.M., enclosing the invitation letter and informed consent forms. The survey was then administered by trained telemedicine case managers per vessel. The invitation letter contains a brief introduction to the study purpose, procedures, declaration of participant anonymity, and voluntary participation. Besides, the participants were assured of the privacy and confidentiality of the response. The participant who chose to participate provided their signed informed consent before participation in the study.

2.3. Data Collection

Data were collected using a standardized and anonymous questionnaire, and the tool has four core parts. The first part of the questionnaire contains the socio-demographic information included age, gender, educational status, nationality, and marital status. The second section of the questionnaire was occupational characteristics, including rank, work-site, job duration at sea, working hours per week. The third part of the questionnaire contains a history of high blood pressure (hypertension), history of diabetes, physical measurement (weight and height), alcohol consumption, and cigarette smoking status. As for the measured high blood pressure (hypertension) was ascertained with the following questions. Has a doctor or other health professional ever told you that you have high blood pressure (hypertension)? The question has only two options, "Yes" and "No". Among those who answered "Yes" to the above question, they were further asked, "Are you currently receiving medicine for your high blood pressure (Hypertension)?". This question also has two choices, "Yes" and "No". Participants who answered "yes" to the above medicine question were also asked to show any antihypertensive medication they were currently taking. Regarding self-reported hypertension (HTN), in this study, it was defined as having a past hypertensive diagnosis and currently using medication due to hypertension. As for the diabetes mellitus, the self-reported diabetic Mellitus was assessed by asking, "Have you ever been told by a doctor or other health worker that you have raised blood sugar levels or diabetes?" The question has two options "Yes" and "No" and the subjects who answered yes to the above question were further asked, "Are you currently taking medicine for high blood sugar level?" The subjects who were taking medicine for high blood sugar levels were further asked to show any drug currently they were receiving due to diabetic Mellitus. In this study, self-reported diabetic mellitus (DM) was defined as having a past diabetic mellitus diagnosis and a current diabetic mellitus treatment. The current smoking was assessed by asking, "Do you currently smoke any tobacco products?" The question has two choices "Yes," "No". The participants who answered "Yes" for the above question were further asked, "do you currently smoked tobacco products daily?" Again, the participants who answered the above question "Yes" further assessed how many years they smoked cigarettes without stopping.

In this study, the current smoking was defined as the participants who smoked cigarettes regularly for a year and had not stopped smoking tobacco products at least six months. According to the World Health Organization (WHO) guideline [26], the study subjects' body weight and height were measured. We then calculated body mass index as weight in kilograms (kg) divided by height in meter (m) squared (Weight (kg)/height $(m)^2$). BMI was also classified into underweight (<18.5 kg/m^2), normal body weight (18.5–24.99 kg/m^2), overweight (25–29.99 kg/m^2) and obesity (≥30 kg/m^2). The questionnaire was designed for the Google survey tool (Google Forms) and the link shared to the C.I.R.M.

2.4. Statistical Analysis

Descriptive statistics included frequency and percentages, were determined for categorical variables to understand the distribution of socio-demographic and occupational characteristics by seafarer's rank. We used the chi-square test to determine whether the socio-demographic and occupational characteristics were distributed homogenously by rank group and to evaluate their association with the prevalence and clustering of modifiable cardiovascular disease risk factors. The independent-sample t-test was used to examine the mean differences of continuous variables between officers and non-officers. The prevalence and clustering of the modifiable CVD risk factors were determined by Socio-demographic (age, marital status, educational level, and nationality) and occupational (rank, worksite, job duration at sea, and working hours per week) characteristics. The educational level of the participants was grouped into three categories, namely, high (completed college or university), middle (completed high school and technical school), and low (secondary and lower school). Moreover, the rank was categorized into officers (captain, deck, and engine officers) and non-officer (deck crew, engine crew, galley, and others).

The multinomial logistic regression model was performed to identify independent predictors for the cardiovascular disease risk factor clustering. Socio-demographic and occupational variables with p-values less than 0.25 in the univariate analysis were selected and entered multinomial logistic regression model. The clustering of modifiable CVD risk factors (dependent variable) was formed from the four modifiable risk factors: hypertension, diabetic mellitus, current smoking, and overweight or obesity. The categories were: (1) no risk factors, (2) one risk factor, and (3) two or three or four risk factors. Finally, having (1) one risk factor and (≥2) two and more than two risk factors versus (0) no risk factors (reference group) were analyzed in the model. Finally, adjusted Odds Ratio (OR) and 95% of confidence interval (95%CI) were reported.

Statistical analyses were performed using R-software [27], version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria). R-package '*dplyr*' was used for data manipulation [28], and R-package '*summarytools*' was used for frequencies tables, cross-tabulation, and other descriptive statistics [29]. R-package 'tidystats' was used for *chisq.test()* function and R-package 'nnet' was used for running the multinomial logistic regression model [30,31]. A two-tailed p-value less than 0.05 was considered statistically significant.

3. Results

3.1. Socio-Demographic and Occupational Characteristics

Out of a total of 8125 seafarers aged ≥18 years on selected vessels, 4648 seafarers volunteered to participate in the survey, with a response rate of 57.2%. We then excluded 330 participants due to missing data. Hence, a total of 4318 subjects were included in the analysis. As presented in Table 1, out of 4318 participants, 44.7% and 55.3% were officers and non-officers, respectively. The mean age of the participants was 37.94 + 10.32 (range: 19–70 years). Almost all (99.4%) participants were male, and more than seventy percent were from non-EU countries. Of the 3069 participants from non-EU countries, 58.7% and 36.7% were Filipino and Indian, respectively. More than three-fifths (69.8%) of study subjects were married, and 55.55% were deck workers. The average working hours per week was 65.96 + 10.96. 35.5% and 7.9% of officers and 38.7% and 8.6% of non-officers were overweight and obese, respectively. Some 71.5% officers and 53.3% of non-officers respectively had a high and middle level of education. Besides, 45.6% of the study subjects had 10 to 20 years job duration at sea (Table 1).

Table 1. Distribution of socio-demographic, occupational, and other relevant characteristics of participants by the rank group.

Variables	Total (%)	Rank		*p*-Value
		Officer, n (%)	Non-Officer n (%)	
Number, n (%)	4318 (100.0)	1929 (44.7)	2389 (55.3)	
Age (in years), mean (SD)	37.94 ± 10.32	38.39 ± 9.89	37.58 ± 10.60	0.011
Gender (male)	4290 (99.4)	1925 (99.8)	2365 (98.9)	-
Nationality				
EU-countries	1222 (28.3)	782 (40.5)	440 (18.4)	<0.001
Non-EU countries	3096 (71.7)	1147 (59.5)	1949 (81.6)	
Marital status				
Single	1303 (30.2)	526 (27.3)	777 (32.5)	0.001
Married	3015 (69.8)	1403 (72.7)	1612 (67.5)	
Educational level				
Higher	1741 (40.3)	1375 (71.3)	366 (15.3)	<0.001
Middle	1803 (41.7)	530 (27.5)	1273 (53.3)	
Low	774 (18)	24 (1.2)	750 (31.4)	
Worksite				
Deck	2396 (55.5)	1167 (60.5)	1229 (51.4)	<0.001
Engine	1468 (34)	762 (39.5)	706 (29.6)	
Galley	454 (10.5)	0 (0)	454 (19)	
Job duration at sea				
<10 years	1551 (35.9)	481 (24.9)	1070 (44.8)	<0.001
10–20 years	1967 (45.6)	1000 (40.4)	967 (40.5)	
21+ years	800 (18.5)	448 (14.7)	352 (14.7)	
Working hours per week, mean (SD)	65.96 ± 10.98	65.67 ± 10.4	66.19 ± 11.4	0.122
Body mass index (BMI)				
Underweight	34 (0.8%)	8 (0.4%)	26 (1.0%)	<0.001
Normal	2355 (54.5%)	1123 (58.2%)	1232 (51.6%)	
Overweight	1571 (36.4%)	646 (33.5%)	925 (38.7%)	
Obesity	358 (8.3%)	152 (7.9%)	206 (8.6%)	

3.2. Prevalence of Modifiable CVD Risk Factors

3.2.1. Self-Reported Hypertension

The prevalence of reported hypertension was 20.8% (95% CI: 19.6% to 22.1%). 18.5% and 27.7% of officers and non-officers respectively had reported hypertension and the prevalence of reported hypertension was significantly higher among non-officers than officers (22.7% vs. 18.5%). The prevalence of reported hypertension was high in study subjects who had married, older age groups, had a lower education level, had long job duration at sea and in deck workers regardless of rank (Table 2). Irrespective of rank, the prevalence of hypertension increased with working hours per week, from 14.1% in participants working <56 h per week to 32.2% in those working >71 h per week.

Table 2. Prevalence (95% CI) of modifiable risk factors of cardiovascular disease and its distribution by socio-demographic and occupational characteristics among seafarers.

	Self-Reported Hypertension	Self-Reported Diabetes	Self-Reported Current Smoking	Overweight or Obesity
Total	20.8 (19.6–22.1)	8.5 (7.7–9.4)	32.5 (31.2–33.9)	44.7 (43.2–46.2)
Age group (in years)				
19–30	3.6 (2.7–4.9)	0.3 (0.10–0.89)	36.3 (33.6–39.0)	33.8 (31.2–36.6)
31–40	16.6 (14.7–18.7)	5.2 (4.3–6.9)	32.9 (30.5–35.5)	43.5 (40.9–46.2)
41–50	35 (32.2–37.8)	13.4 (11.5–15.5)	25.7 (23.2–28.3)	50.4 (47.4–53.3)
51+	41.6 (37.3–47.9)	25.9 (22.3–29.9)	37.9 (33.7–42.3)	60.9 (56.6–65.2)
p-value	<0.001	<0.001	<0.001	<0.001
Nationality				
EU-countries	22.6 (20.3–25.0)	9.2 (7.7–11.0)	41.5 (38.7–44.3)	45.8 (43–48.6)
Non-EU countries	20.2 (18.8–21.6)	8.2 (7.2–9.2)	29.2 (27.4–30.6)	44.2 (42.5–45.9)
p-value	0.084	0.279	<0.001	0.356
Marital status				
Single	9.8 (8.2–11.5)	2.3 (1.6–3.3)	34.3 (31.7–36.9)	33.7 (31.2–36.3)
Married	25.6 (24.1–27.2)	11.2 (10–12.3)	31.8 (30.2–33.5)	49.9 (47.6–51.2)
p-value	<0.001	<0.001	0.111	<0.001
Educational level				
Higher	15.2 (13.4–16.8)	7.4 (6.2–8.8)	28.7 (26.6–30.9)	37.5 (35.2–39.8)
Middle	23.7 (21.8–25.8)	8.7 (7.4–10.0)	36.7 (34.4–38.9)	47.1 (44.8–49.4)
Low	27.2 (24–30.4)	10.5 (8.4–12.9)	31.5 (28.3–34.9)	55.3 (51.7–58.8)
p-value	<0.001	0.037	<0.001	<0.001
Rank				
Officer	18.5 (16.8–20.3)	7.7 (6.5–8.9)	30.2 (28.2–32.3)	41.4 (39.2–43.6)
Non-officer	22.7 (21–24.5)	9.2 (8.0–10.4)	34.5 (32.5–36.4)	47.3 (45.3–49.4)
p-value	<0.001	0.099	0.003	<0.001
Worksite				
Deck	23.5 (21.8–25.2)	8.1 (7.1–9.3)	33.5 (31.6–34.4)	43.7 (41.7–45.7)
Engine	18.5 (16.6–20.6)	9.7 (8.3–11.4)	31.5 (29.1–33.9)	44.5 (41.9–47.1)
Galley	14.5 (11.5–18.2)	6.2 (4.2–8.9)	31 (26.9–35.6)	50.2 (45.6–54.9)
p-value	<0.001	0.038	0.338	0.038
Job duration at sea				
<10 years	6.6 (5.5–8.0)	1.4 (0.9–2.1)	34.4 (32.2–36.8)	32.2 (29.7–34.5)
10–20 years	26.5 (24.6–28.5)	9.9 (8.7–11.4)	31.6 (29.6–33.7)	49.5 (47.2–51.7)
21+ years	34.5 (31.2–37.9)	18.6 (16–21.5)	31.3 (28.1–34.6)	57.4 (53.9–60.8)
p-value	<0.001	<0.001	0.156	<0.001
Working hours per week				
≤56 h				
57–70 h	14.1 (12.2–16.3)	5.4 (4.1–6.9))	25.7 (23.2–28.4)	38.0 (35.2–40.9)
71+ h	19.2 (17.6–20.9)	9.1 (7.9–10.4))	32.2 (30.3–34.2)	46.5 (44.4–48.6)
p-value	32.2 (29.3–35.2)	10.6 (8.8–12.8)	40.9 (37.9–44.2)	48.3 (45–51.5)
	<0.001	<0.001	<0.001	<0.001

3.2.2. Self-Reported Diabetes

Out of the total, 366 (8.5%) participants had reported diabetic mellitus. The prevalence of reported diabetic mellitus was higher in study participants who had married (11.2% (10.0% to 12.3%)) compared with single (2.3% (1.6% to 3.3%)). The prevalence of diabetes mellitus (DM) increased significantly with age, from 0.3% in the age group 19–30 years to 25.9% in the age ≥51 years. This risk factor's prevalence was higher among the participants who had 21 years and above job duration at sea, working 71 h and more per week. The proportion of DM was increased with the decreasing level of education regardless of rank. As for the worksites, the engine workers had a high prevalence of DM irrespective of rank. Variables included rank and nationality, were not significantly associated with the prevalence of self-reported DM (Table 2).

3.2.3. Self-Reported Current Smoking

Reported current smoking was observed in 32.5% (95% CI: 31.2% to 33.9%) of the total participants. As shown in Table 2, age groups, nationality, educational level, rank, and working hours per week were significantly associated with the prevalence of reported current smoking. In contrast, variables included marital status, worksites, and job duration at sea were not associated with current smoking. Current smoking varied significantly with age groups and was higher in non-officers than officers (34.5% vs. 30.2%). The prevalence of reported current smoking was increased with working hours per week, from 25.7% in participants who had worked ≤56 h to 40.9% in those working 71 h or more per week.

3.2.4. Overweight or Obesity

Some 44.7% (95% CI: 43.2% to 46.2%) of the total participants were overweight or obese. As presented in Table 2, except nationality all socio-demographic and occupational variables were significantly associated with prevalence of the overweight or obese. The prevalence of the overweight or obese was increased with the increasing the age, working hours per week and job duration at sea regardless of rank. In contrast, this risk factor was increased with the decreasing levels of education. It was observed relatively high in non-officers compared to officers (47.3% vs. 41.4%). Besides, the prevalence of overweight or obese was found to be high in participants who had married than single (49.9% vs. 33.7%) (Table 2).

As shown in Table 3, the prevalence of CVD risk factors, except self-reported current smoking increased with age both in officers and non-officers. Reported hypertension and diabetes prevalence increased with the decreasing the level of education in non-officers, but not in officers.

Among non-officers, the prevalence of modifiable CVD risk factors increased with working hours per week. In contrast, CVD risk factors prevalence, except reported hypertension varied significantly with working hours per week among officers. The proportion of overweigh or obesity and reported diabetes increased with the length of work at sea both in officers and non-officers. Educational levels and nationality were not associated with reported hypertension and diabetes among officers. In addition, working hours per week was not associated with hypertension in officers (Table 3).

Table 3. Prevalence (95% CI) of modifiable CVD risk factors by socio-demographic and occupational characteristics stratified by rank.

Rank Group	Self-Reported Hypertension	Self-Reported Diabetes	Self-Reported Current Smoking	Overweight or Obesity
Officer				
Overall	18.5 (16.8–20.3)	7.7 (6.5–8.9)	30.2 (28.1–32.3)	41.4 (39.2–43.6)
Age group (in years)				
19–30	5.1 (3.4–7.6)	0.2 (0.01–1.4)	36.2 (31.9–40.7)	30.9 (26.7–35.3)
31–40	14.8 (12.3–17.6)	1.5 (0.8–2.8)	32.7 (29.3–36.3)	39.0 (35.4–42.7)
41–50	26.3 (22.6–30.4)	15.4 (12.4–18.9)	18.5 (15.3–22.2)	43.5 (39.2–47.9)
51+	40.4 (33.9–47.1)	25.0 (19.6–31.2)	36.0 (29.8–42.6)	65.8 (59.2–71.8)
p-value	<0.001	<0.001	<0.001	<0.001
Nationality				
EU-countries	19.7 (16.9–22.7)	7.9 (6.2–10.1)	38.9 (35.5–42.4)	44.1 (40.6–47.7)
Non-EU countries	17.7 (15.6–20.1)	7.5 (6.1–9.2)	24.2 (21.8–26.8)	39.5 (36.7–42.4)
p-value	0.295	0.794	<0.001	0.058
Marital status				
Single	12.9 (10.2–16.2)	4.0 (2.6–6.1)	33.7 (29.7–37.9)	28.9 (25.1–33.0)
Married	20.6 (18.5–22.8)	9.1 (7.6–10.7)	28.9 (26.5–31.3)	46.0 (43.4–48.7)
p-value	<0.001	<0.001	0.047	<0.001
Educational level				
Higher	17.5 (15.6–19.7)	8.4 (6.9–9.9)	28.2 (25.9–30.7)	37.6 (35.0–40.2)
Middle	21.5 (18.1–25.3)	6.2 (4.4–8.7)	33.0 (29.1–37.2)	49.2 (44.9–53.6)
Low	8.3 (1.5–2.8)	0.0	79.2 (57.2–92.1)	83.3 (61.8–94.5)
p-value	0.058	0.106	<0.001	<0.001
Worksite				
Deck	18.8 (16.6–21.2)	6.2 (4.9–7.7)	31.1 (28.5–33.9)	42.9 (40.1–45.8)
Engine	18.1 (15.1–21.1)	10.0 (7.9–12.4)	28.7 (25.6–32.1)	39.0 (35.5–42.5)
Galley	—	—	—	—
p-value	N/A	N/A	N/A	N/A
Job duration at sea				
<10 years	6.0 (4.1–8.6)	0.4 (0.07–1.7)	33.5 (29.3–37.9)	26.0 (22.2–30.2)
10–20 years	16.6 (14.4–19.1)	5.8 (4.5–7.5)	30.8 (27.9–33.9)	41.6 (38.5–44.7)
21+ years	36.2 (31.7–40.8)	19.6 (16.1–23.7)	25.2 (21.3–29.6)	57.4 (52.6–61.9)
p-value	<0.001	<0.001	0.019	<0.001
Working hours per week				
≤56 h	21.3 (17.9–25.2)	5.7 (3.9–8.2)	25.4 (21.7–29.5)	37.9 (33.7–42.3)
57–70 h	16.8 (14.6–19.3)	10.6 (8.8–12.7)	32.5 (29.6–35.5)	45.2 (42.1–48.3)
71+ h	19.1 (15.5–23.3)	2.9 (1.6–5.2)	30.3 (25.9–34.9)	36.3 (31.7–41.2)
p-value	0.102	<0.001	0.018	0.002
Non-officer				
Overall	22.7 (21.1–24.5)	9.2 (8.0–10.4)	34.5 (32.5–36.4)	47.3 (45.3–49.4)
Age group (in years)				
19–30	2.7 (1.7–4.2)	1.8 (1.0–3.1)	36.3 (32.9–39.9)	35.7 (32.3–39.2)
31–40	18.6 (15.8–21.7)	9.2 (7.2–11.6)	33.1 (29.7–36.8)	48.3 (44.5–52.1)
41–50	41.9 (38.1–45.8)	11.1 (8.9–13.9)	31.4 (27.8–35.1)	55.8 (51.9–59.7)
51+	42.6 (36.8–48.5)	23.9 (19.2–29.3)	39.4 (33.8–45.4)	57.1 (51.2–62.8)
p-value	<0.001	<0.001	<0.055	<0.001
Nationality				
EU-countries	27.7 (23.6–32.2)	9.3 (6.8–12.5)	46.1 (41.4–50.9)	48.9 (44.1–53.6)
Non-EU countries	21.6 (19.8–23.5)	9.0 (7.9–10.5)	31.8 (29.7–33.9)	47.0 (44.8–49.2)
p-value	0.007	0.949	<0.001	0.513

Table 3. *Cont.*

Rank Group	Self-Reported Hypertension	Self-Reported Diabetes	Self-Reported Current Smoking	Overweight or Obesity
Marital status				
Single	7.6 (5.9–9.7)	2.2 (1.3–3.6)	34.7 (31.4–38.2)	36.9 (33.6–40.5)
Married	30.0 (27.8–32.3)	12.5 (10.9–14.5)	34.3 (31.9–36.7)	52.4 (49.9–54.8)
p-value	<0.001	<0.001	0.343	<0.001
Educational level				
Higher	5.7 (3.7–8.8)	3.8 (2.2–6.5)	30.6 (25.9–35.6)	36.9 (31.9–42.1)
Middle	24.7 (22.3–27.1)	9.7 (8.1–11.5)	38.2 (35.5–40.9)	46.2 (43.4–48.9)
Low	27.7 (24.6–31.1)	10.8 (8.7–13.3)	30.0 (26.8–33.4)	54.4 (50.7–57.9)
p-value	<0.001	<0.001	<0.001	<0.001
Worksite				
Deck	27.9 (25.4–30.5)	10.0 (8.4–11.9)	35.7 (33.0–38.5)	44.5 (41.7–47.3)
Engine	19.0 (16.2–22.1)	9.5 (7.5–11.9)	34.4 (30.9–38.1)	50.4 (46.7–54.2)
Galley	14.5 (11.5–18.2)	6.2 (4.2–8.9)	31.1 (26.9–35.6)	50.2 (45.5–54.9)
p-value	<0.001	0.048	0.203	0.015
Job duration at sea				
<10 years	6.9 (5.5–8.6)	1.8 (1.1–2.8)	34.8 (31.9–37.7)	34.8 (31.9–37.7)
10–20 years	36.7 (33.7–39.8)	14.3 (12.1–16.7)	32.5 (29.5–35.5)	57.4 (54.4–60.7)
21+ years	32.4 (27.6–37.6)	17.3 (13.6–21.8)	38.9 (33.8–44.3)	57.6 (52.0–62.6)
p-value	<0.001	<0.001	0.089	<0.001
Working hours per week				
≤56 h	8.1 (6.2–10.7)	5.0 (3.5–7.2)	25.9 (22.5–29.6)	38.1 (34.3–42.1)
57–70 h	21.2 (18.9–23.6)	7.8 (6.4–9.5)	32.0 (29.4–34.7)	47.5 (44.6–50.4)
71+ h	41.5 (37.5–45.7)	16.2 (13.3–19.5)	48.7 (44.5–52.9)	56.9 (52.7–60.9)
p-value	<0.001	<0.001	<0.001	<0.001

3.3. Clustering of Modifiable CVD Risk Factors

The clustering of modifiable CVD risk factors was categorized into three classes. The classes were no risk factors, having one risk factor and clustering two and more than two risk factors (Table 4). In general, 68.5% (95% CI: 67.2% to 69.9%) and 28.3% (26.9% to 29.7%) of the study subjects respectively, had at least one and at least two modifiable CVD risk factors. Overall, 31.4 %(30.0% to 32.8%), 40.3 (38.8% to 41.8%), 20.9 % (19.7% to 22.2%), 6% (5.4% to 6.8%) and 1.3% (1.0% to 1.7%) of the study participants respectively had zero, one, two, three and four modifiable CVD risk factors. As for the rank, 33.4 % of officers and 29.8% of non-officers had no CVD risk factors.

In contrast, 43.5% and 23.1% of officers and 37.7% and 32.5% of non-officers had one and at least two modifiable risk factors, respectively. The prevalence of having at least two risk factors increased significantly among non-officers compared with officers. The prevalence of having at least two risk factors increased significantly with age, from 13.3% in the age group 19–30 years to 51.3% in age ≥51 years. On the other hand, the prevalence of at least two risk factors of CVD increasing with the decreasing the level of education. However, the proportion of having at least two risk factors significantly increased with increasing the job duration at sea and working hours per week regardless of rank (Table 3).

As for the combination of the CVD risk factors, self-reported current smoking/ overweight or obesity (30.9% (28.9% to 32.9%)), overweight or obesity/self-reported hypertension (27.5% (25.6% to 29.5%)), and self-reported current smoking/self-reported hypertension (17.5% (15.9% to 19.2%)) were the three most common of all two modifiable CVD risk factor clustering. Besides, the combination of overweight or obesity/self-reported hypertension/self-reported current smoking (70.0% (64.0% to 75.3%) were the most often clustering of three modifiable CVD risk factors. Among the participants with only one risk factors, 49.2% were overweight or obesity, 35.3% were current smokers, 10.9% had hypertension and 4.6% had diabetes.

Table 4. Prevalence (95% CI) of modifiable CVD risk factor clustering based on socio-demographic and occupational characteristics among seafarers.

Category	None	One	Clustering (≥2)	*p*-Value
Total	31.4 (30.0–32.8)	40.3 (38.8–41.8)	28.3 (26.9–29.7)	
Age group (in years)				
19–30	39.3 (36.5–42.1)	47.5 (44.6–50.2)	13.3 (11.5–15.3)	<0.001
31–40	33.5 (31.0–36.0)	41.3 (38.7–43.9)	25.2 (22.9–27.5)	
41–50	28.9 (26.4–31.7)	33.2 (30.5–35.9)	37.8 (35.0–40.7)	
51+	12.6 (9.9–15.8)	36.2 (32.1–40.5)	51.3 (46.9–55.6)	
Nationality				
EU-countries	24.9 (22.5–27.4)	42.8 (40–45.6)	32.3 (29.7–35.0)	<0.001
Non-EU countries	34.0 (32.4–35.7)	39.3 (37.6–41)	26.7 (25.2–28.3)	
Marital status				
Single	39.9 (37.3–42.7)	45.2 (42.3–47.8)	14.9 (13.0–17.0)	<0.001
Married	27.7 (26.2–29.4)	38.2 (36.5–39.9)	34.1 (32.4–35.8)	
Educational level				
Higher	38.5 (36.2–40.8)	41.6 (39.3–43.9)	19.9 (18.1–21.9)	<0.001
Middle	26.2 (24.2–28.3)	42.2 (39.9–44.5)	31.7 (29.5–33.9)	
Low	27.8 (24.7–31.0)	32.9 (29.7–34.4)	39.3 (35.8–42.8)	
Rank				
Officer	33.4 (31.3–35.6)	43.5 (41.3–45.7)	23.1 (22.3–25.1)	<0.001
Non-officer	29.8 (28.0–31.7)	37.7 (35.7–39.7)	32.5 (30.6–34.4)	
Worksite				
Deck	31.9 (30.0–33.8)	37.8 (35.8–39.7)	30.3 (28.5–32.2)	<0.001
Engine	29.2 (26.9–31.6)	45.8 (43.3–48.4)	25.0 (22.8–27.3)	
Galley	36.3 (31.9–40.9)	35.5 (30.0–40.0)	28.2 (24.1–32.6)	
Job duration at sea				
<10 years	42.8 (40.4–45.3)	42.0 (39.6–44.5)	15.2 (13.4–17.1)	<0.001
10–20 years	26.8 (24.9–28.8)	40.0 (37.8–42.2)	33.2 (31.1–35.3)	
21+ years	20.8 (18.0–23.8)	37.5 (34.2–40.9)	41.8 (38.3–45.3)	
Working hours per week				
≤56 h	43.7 (40.8–46.7)	36.0 (33.2–38.9)	20.3 (17.9–22.7)	<0.001
57–70 h	28.5 (26.6–30.4)	43.2 (41.1–45.3)	28.3 (26.5–30.3)	
71+ h	24.0 (21.5–26.9)	38.6 (35.5–41.7)	37.3 (34.3–40.5)	

The prevalence of modifiable CVD risk factor clustering by socio-demographic and occupational characteristics stratified by rank is presented in Table 5. Consequently, the prevalence of having at least two modifiable CVD risk factors was higher in older ages, in both officers and non-officers. The prevalence of having two or more CVD risk factors increased with working hours per week among non-officers, but not in officers. However, the prevalence of at least two CVD risk factors differed significantly with the working hours per week among officers. The proportion of having ≥2 risk factors increased with the working hours per week in non-officers and with the job duration at sea among officers. The clustering of two and more than two CVD risk factors found to be more favorable in both officers and non-officers who had married than single and the differences was also statistically significant.

As summarized in Table 6, multinomial logistic regression analysis showed that study subjects aged 51 years and above 3.92 times more likely to have at least two CVD risk factors compared to those aged from 19–30 years. Non-officers (OR: 1.36, 95% CI:1.09–1.70) were more likely to have at least two CVD risk factors when compared to officers. Participants from EU countries were 1.38 and 1.60 more likely to have one and at least two CVD risk factors than those from non-EU countries. Study subjects working 71 h and above per week and had 21 and above job duration at sea were more likely to have both one, and at least two risk factors compared with those who were working less than or equal to 56 h, and had less ten years work experiences, respectively. Besides, study individuals who had lower level of education were more likely to have at least two CVD risk factors when compared to high level of education. Variables included educational level (middle vs. higher), nationality, job duration at sea and working hours per week were independent predictors for both having one and at least two modifiable CVD risk factors. On the other hand, age, marital status, and rank were important predictors for having at least two modifiable CVD risk factors (Table 6).

Table 5. Prevalence (95% CI) of modifiable CVD risk factor clustering among seafarers stratified by rank.

Rank Group	None	One	Clustering (≥2)	*p*-Value
Officer				
Overall	33.4 (31.3–35.6)	43.5 (41.3–45.7)	23.1 (22.3–25.1)	
Age group (in years)				
19–30	39.8 (35.4–44.4)	48.3 (43.7–52.9)	11.9 (9.2–15.3)	<0.001
31–40	37.6 (34.1–42.3)	42.2 (38.6–45.9)	20.2 (17.4–23.4)	
41–50	30.8 (26.9–35.0)	43.7 (39.3–48.1)	25.5 (21.8–29.6)	
51+	12.7 (8.8–17.9)	37.3 (31.0–43.9)	50.0 (43.6–56.4)	
Nationality				
EU-countries	28.9 (25.8–32.2)	42.2 (38.7–45.8)	28.9 (25.8–32.2)	<0.001
Non-EU countries	36.4 (33.6–39.3)	44.4 (41.5–47.3)	19.2 (16.9–21.6)	
Marital status				
Single	44.3 (40.0–48.7)	41.4 (37.2–45.8)	14.3 (11.4–17.6)	<0.001
Married	29.3 (26.9–31.8)	44.3 (41.6–46.9)	26.4 (24.2–28.8)	
Educational level				
Higher	36.6 (34.0–39.2)	43.2 (40.6–45.9)	20.2 (18.1–22.5)	<0.001
Middle	26.2 (22.6–30.2)	45.5 (41.2–49.8)	28.3 (24.5–32.4)	
Low	8.3 (1.5–28.5)	16.7 (5.5–38.2)	75.0 (52.9–89.4)	
Worksite				
Deck	32.8 (30.1–35.6)	43.2 (40.3–46.1)	24.0 (21.6–26.6)	N/A
Engine	34.3 (30.9–37.8)	44.0 (40.4–47.6)	21.8 (18.9–24.9)	
Galley	—	—	—	
Job duration at sea				
<10 years	47.6 (43.1–52.2)	40.7 (36.3–45.3)	11.6 (8.9–14.9)	<0.001
10–20 years	32.8 (29.9–35.8)	45.9 (42.8–49.0)	21.3 (18.8–23.9)	
21+ years	19.4 (15.9–23.5)	41.1 (36.5–45.8)	39.5 (34.9–44.2)	
Working hours per week				
≤56 h	40.2 (35.9–44.7)	37.9 (33.7–42.3)	21.9 (18.4–25.8)	<0.001
57–70 h	28.9 (26.2–31.9)	45.3 (42.5–48.7)	25.5 (22.8–28.3)	
71+ h	35.8 (31.2–40.7)	45.6 (40.4–50.2)	18.8 (15.3–23.1)	
Non-officer				
Overall	29.8 (28.0–31.7)	37.7 (35.7–39.7)	32.5 (30.6–34.4)	
Age group (in years)				
19–30	39.0 (35.5–42.5)	46.9 (43.4–50.5)	14.1 (11.8–16.8)	<0.001
31–40	29.2 (25.9–32.8)	40.4 (36.7–44.2)	30.4 (26.9–33.9)	
41–50	27.5 (24.1–31.2)	24.9 (21.6–28.4)	47.6 (43.7–51.5)	
51+	12.5 (8.9–16.9)	35.3 (29.8–41.1)	52.2 (46.3–58.1)	
Nationality				
EU-countries	17.7 (14.3–21.7)	43.9 (39.2–48.6)	38.4 (33.9–43.2)	<0.001
Non-EU countries	32.6 (30.5–34.7)	36.3 (34.1–38.5)	31.1 (29.1–33.3)	
Marital status				
Single	37.1 (33.7–40.6)	47.5 (43.9–51.1)	15.4 (13.1–18.2)	<0.001
Married	26.4 (24.2–28.6)	32.9 (30.7–35.3)	40.7 (38.3–43.1)	

Table 5. *Cont.*

Rank Group	None	One	Clustering (≥2)	*p*-Value
Educational level				
Higher	45.6 (40.5–50.9)	35.5 (30.7–40.7)	18.9 (15.1–23.3)	<0.001
Middle	26.2 (23.8–28.7)	40.8 (38.1–43.5)	33.1 (30.5–35.7)	
Low	28.4 (25.2–31.8)	33.5 (30.1–36.9)	38.1 (34.7–41.7)	
Worksite				
Deck	31.0 (28.4–33.7)	32.6 (30.0–35.3)	36.4 (33.7–39.1)	<0.001
Engine	23.7 (20.6–27.0)	47.9 (44.0–51.6)	28.5 (25.2–31.9)	
Galley	36.3 (31.9–40.9)	35.5 (31.1–40.1)	28.2 (24.1–32.6)	
Job duration at sea				
<10 years	40.7 (37.7–43.7)	42.6 (39.6–45.6)	16.7 (14.5–19.1)	<0.001
10–20 years	20.6 (18.1–23.3)	33.0 (30.9–37.0)	45.5 (42.3–48.7)	
21+ years	22.4 (18.3–27.2)	33.9 (28.1–38.2)	44.6 (39.4–49.9)	
Working hours per week				
≤56 h	46.6 (42.6–50.6)	34.5 (30.8–38.5)	18.9 (15.9–22.3)	<0.001
57–70 h	28.1 (25.6–30.7)	41.2 (38.4–44.0)	30.8 (28.2–33.5)	
71+ h	15.7 (12.8–18.9)	33.7 (29.9–37.8)	50.6 (46.5–54.8)	

Table 6. Multinomial logistic regression analysis of modifiable cardiovascular disease risk factor clustering among seafarers (n = 4318).

Category	One		Clustering (≥2)	
	OR (95% CI)	*p*-Value	OR (95% CI)	*p*-Value
Age group (in years)				
19–30	1	-	1	-
31–40	0.85 (0.78–1.10)	0.219	1.02 (0.74–1.39)	0.913
41–50	0.92 (0.86–1.23)	0.068	1.27 (0.89–1.83)	0.193
51+	1.04 (0.67–1.61)	0.871	3.92 (2.44–6.29)	<0.001
Marital status				
Single	1		1	
Married	1.18 (0.97–1.43)	0.114	1.59 (1.24–2.03)	<0.001
Educational level				
Higher	1		1	
Middle	1.56 (1.30–1.88)	<0.001	2.21 (1.78–2.75)	<0.001
Low	1.25 (0.97–1.62)	0.084	2.48 (1.87–3.30)	<0.001
Nationality				
Non-EU countries	1		1	
EU-countries	1.38 (1.16–1.64)	<0.001	1.60 (1.31–1.95)	<0.001
Rank				
Officer	1		1	
Non-officer	1.07 (0.88–1.31)	0.485	1.36 (1.09–1.70)	0.007
Job duration at sea				
<10 years	1		1	
10–20 years	2.22 (1.77–2.79)	<0.001	2.73 (2.09–3.57)	<0.001
21+ years	2.37 (1.68–3.35)	<0.001	2.60 (1.79–3.78)	<0.001
Working hours per week				
≤56 h	1		1	
57–70 h	1.73 (1.46–2.05)	<0.001	2.03 (1.65–2.49)	<0.001
71+ h	1.88 (1.52–2.33)	<0.001	3.08 (2.42–3.92)	<0.001

4. Discussion

This cross-sectional epidemiological study has assessed the prevalence and clustering of reported modifiable CVD risk factors among seafarers. This study is the first study to evaluate the prevalence and clustering of reported modifiable CVD risk factors among seafarers with a large representative sample. As a result, the prevalence of reported hypertension, diabetes, current smoking, and overweight or obesity was 20.8%, 8.5%, 32.5%, and 44.7%, respectively. The most important modifiable CVD risk factor in both officers and non-officers was overweight or obesity. Compared with the previous studies [16,20,21], the prevalence of hypertension among seafarers was less in our study. There are several reasons why the prevalence of hypertension might have less in our study than in previous studies among seafarers. First, we evaluated self-reported hypertension and did not consider participants who were not taking antihypertensive treatment, although they have high blood pressure levels. These could be the reasons that underestimate the proportion of this risk factor in the present study. However, our finding was almost in line with the study conducted among Iranian seafarers and greater than the study conducted on Italian flag vessels regardless of the difference in methods [17,18].

Regardless of the difference in methods, we found a higher prevalence of both self-reported current smoking and diabetes than the previous studies carried out in seafarers [19,21]. This study documented that 36.4% and 8.3% of the participants were overweight and obese, respectively. Our result was inconsistent with studies conducted among Danish seafarers [32,33], which reported 70.8% and 76.6% overweight and 30.9% obesity. The differences might be due to differences in the methods and data sources. As for the rank, the prevalence of self-reported modifiable CVD risk factors, except diabetes was significantly higher among non-officers compared with officers. This might be due to work-related stress because, as different studies reported that non-officers work is characterized by long working hours, night shift work, short average sleep time, suffer from frequent sleep interruption, irregular working times, and more physically demanding [9,17,34,35].

Life on board is another environmental stressor for seafarers, especially for non-officers because non-officers stay on board for more extended periods than officers (8.3 months vs. 4.8 months) [35]. Due to night shift work, lack of sleep, and intense activity, seafarers, especially non-officers, experiencing various coping strategies, including smoking cigarettes, and drinking alcohol during at work. Hence, these physical and Psychosocial stressors and high levels of work-related fatigue, lack of leisure time, and physical inactivity lead to high BMI and other modifiable CVD risk factors. Besides, Work-related stressors can affect the body by activating the neuroendocrine stress pathway, and unhealthy individual lifestyle behaviors (unhealthy diet, smoking, heavy alcohol consumption, and physical inactivity) can indirectly affect the body. Several studies in general population [36–40] and seafarers [34,41–43] have reported that work-related stress contributes significantly to modifiable CVD risk factors. A study in the general population reported that work-related stress, characterized by the effort-reward imbalance model, was significantly associated with a high BMI [44]. In another general population study, also work-related stress, described by the effort-reward imbalance model, was associated with metabolic syndromes [45].

The present study reports that more than four in six (68.5%) seafarers aged 19 to 70 have at least one of the following modifiable CVD risk factors: reported hypertension, diabetes, current smoking, and overweight or obesity. Besides, the clustering of two or more two CVD risk factors was noted in 28.5% of study participants. We found that significantly higher prevalence of two or more CVD risk factors among non-officers compared with officers. It is suggested that the non-officer work accompanied with the exposure to different work-related stressors may have unfavorable effects on cardiovascular health conditions in non-officers. Our finding was inconsistent with the study conducted on German-flagged ships, which reported a higher prevalence of coronary heart disease (CHD) risk factor clustering (>3 risk factors) among officers than non-officers (crew ranks) [16]. These differences could be due to differences in methods and CVD risk factor profiles in the study. For example, we did not consider biochemical parameters such as LDL cholesterol, HDL cholesterol, and triglycerides in the present study. Our study documented that the clustering of reported current smoking/overweight or obesity and overweight or obesity/reported hypertension/current smoking was the most among the combination of two and three modifiable CVD risk factors.

We found that 33.4%, 43.5%, and 23.1% of officers and 29.8%, 37.7%, and 32.5% of non-officers respectively had zero, one, and two and more than two CVD risk factors. Another study conducted among seafarers reported that clustering of more than three CHD risk factors was observed in 56.2% of the galley staff, 43.6% of the engine officers, 32.2% of the deck officers, 24.6% of the deck crew, and 17.0% of the engine crew [16]. In the present study, modifiable CVD risk factors were observed more often in study subjects from EU countries with a prevalence between 9.2% and 45.8%. The significantly higher prevalence of both one and at least two modifiable CVD risk factors in participants from EU- countries compared to non-EU-countries mighty be due to their older age. Participants from EU countries were relatively older than those from non-EU countries. Besides, multinomial logistic regression analysis reported that participants from EU-countries 1.60 times more likely to have two and more than two CVD risk factors than those from non-EU countries. Our result was consistent with the study carried out among seafarers regardless of the differences in method, which revealed that European seafarers were 2.4 times more likely to have more than three CHD risk factors than non-European seafarers [16]. Another study reported that the proportion of high blood sugar (30%) was observed in the Croatian sailor [46].

Non-officers in the older age strata (i.e., age of 41 to 50, and age of >51) exhibited a higher prevalence of two and more CVD risk factors compared with the officers. Participants aged 51 and older were approximately four times more likely to have at least two CVD risk factors (OR: 3.92 (95% CI: 2.44–6.29)] than those aged between 19 and 30 years old, while controlling for marital status, rank, educational level, nationality, length of work at sea and working hours per week. This could be due to work-related stressors causing a negative effect on cardiovascular health after a long latency. Older workers may face more work-related stressors, are inactive in physical activity, and more able to complain about the psychological demands of work than younger age groups. Besides, older age is associated with an increased risk of various pathological changes, making older workers more exposed to different physical and psychological stressors than younger workers. A study in seafarers reported increased health problems and fatigue in older workers [47]. The same study found that the interaction between job demands, and age significantly impacted overall mental health and perceived stress [47]. Our study showed that non-officers (OR: 1.36 (95% CI: 1.09–1.70)) were more likely than the officers to have two and more than two modifiable CVD risk factors, while controlling for marital status, age, educational level, nationality, job duration at sea and working hours per week. Our result was not in line with the other previous study carried out in seafarers regardless of the difference in methods [16,48].

In general, this study revealed that non-officers, older age, married, low level of education, working hours per week, EU nationality, and job duration at sea were positively associated with modifiable CVD risk factor clustering, compared to their counterparts. Hence, the present findings may help to develop modifiable CVD risk factors prevention and control strategies onboard ships. As for intervention, for example, non-officers, those who are married, older seafarers ($\geq$51 years), who work long hours per week, those with a low level of education, who have a long duration of work at sea, and seafarers from EU-countries could be screened for modifiable CVD risk factors, in particular for clustering of CVD risk factors. Additionally, these groups should be targeted for early prevention programs to reduce risk factors and prevent cardiovascular diseases, as they are more likely to have a modifiable CVD risk factor clustering.

Telemedicine approach prevention program can be more appropriate for screening the high-risk groups and follow-up visits at sea because Seafarers are hundreds of miles away from the nearest aid point regarding healthcare. Studies have reported that telemedicine has proven effective by providing advice, diagnosis, and treatment to seafarers during emergencies at sea [49]. Besides, it is possible to follow up visits and regular medical examinations onboard ships through telemedicine using new technologies, such as high-speed internet and video conferencing [50,51]. Promoting a healthy lifestyle or behavioral modification efforts is most important to reducing CVD risk factors. Hence, the International Maritime Organization (IMO), together with other responsible bodies and stakeholders, should take into account strategies related to cigarette smoking reduction, including smoking restrictions on board ships. In 2006, the International Labor Organization (ILO) [25] adopted the Maritime Labor Convention (MLC) 2006, and it entered into force on 20 August 2013. In chapter five (title two), the 2006 Convention deals with the timetable working hours and rest hours for seafarers and clearly stated that seafarers' working hours are eight per day with one day of rest per week. However, our study reported that 51.2% and 22.9% of the participants worked 57–70 h and 71+ h per week, respectively. Therefore, the Convention 2006 has not yet been fully applied related to working hours of seafarers on board ships. Hence, the ILO and other responsible bodies should pay attention to its enforcement related to working hours according to the guideline because long working hours per week was one of the independent predictors for modifiable CVD risk factor clustering. As for physical activity, the working conditions of seafarers does not motivate them to carry out daily physical training as on land because there are sudden climate changes, accidents, and physical and psychological stress. However, planned health education regarding physical activity through telemedicine and the provision of simple and easy-to-use mobile applications [52] could encourage the seafarers to practice daily physical exercises to be physically active and reduce the chance of being overweight or obese.

Limitation of this study: this study was a cross-sectional study, and the study design prevents us from determining the causality or temporal relationship between modifiable CVD risk factor clustering and CVD. In the present study, we assessed self-reported modifiable CVD risk factors, except overweight or obesity. We did not include participants who were not on treatment despite having high blood pressure or high blood sugar. Therefore, these could underestimate the prevalence of hypertension or diabetes. Current smoking may be subject to reporting bias as it depends only on the participants' responses. Besides, those who did not smoke regularly were excluded. Hence, the prevalence of current smoking may be underestimated.

5. Conclusions

The results of our study demonstrate that a high prevalence of reported modifiable CVD risk factors was observed in non-officers. This study reported that the clustering of reported current smoking/overweight or obesity and overweight or obesity/reported hypertension/ reported current smoking were the most among the combination of two and three modifiable CVD risk factors; the prevalence was 30.9% and 70.0%, respectively. The present study indicates that non-officers, older workers, European seafarers, participants with a low level of education, who work long hours a week, are married, and have a long job duration at sea are susceptible to modifiable CVD risk factor clustering. Hence, a specific intervention targeting the high-risk groups should be designed and implemented onboard ships. In the present study, we did not consider cholesterol profiles, so a prospective study should be considered in the future to evaluate clustering and predict modifiable CVD risk factors, including cholesterol profiles among seafarers, for further preventive measures.

Author Contributions: G.G.S.: conceptualized and designed the study, analyzed, and interpreted data, methodology, and drafted the initial manuscript. G.B.: contributed to data curation and drafting manuscript. M.D.C.: contributed to the data collection and manuscript preparation. F.A.: reviewed, edited, guided, and approved the study. All authors have read and agreed to the published version of the manuscript.

Funding: This study was partly funded by the ITF Trust, grant number 1276/2018.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the C.I.R.M. ethics, scientific, and medical committee.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: The authors thank data collectors, participants for their cooperation, and all C.I.R.M. staff for their unreserved support for the successful completion of this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Roth, G.A.; Mensah, G.A.; Johnson, C.O.; Addolorato, G.; Ammirati, E.; Baddour, L.M.; Barengo, N.C.; Beaton, A.Z.; Benjamin, E.J.; Benziger, C.P.; et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990–2019: Update from the GBD 2019 Study. *J. Am. Coll. Cardiol.* **2020**, *76*, 2982–3021. [CrossRef]
2. World Health Organization. Cardiovascular Diseases. 16 October 2020. Available online: https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1 (accessed on 24 March 2021).
3. Roberts, S.E.; Jaremin, B. Cardiovascular disease mortality in British merchant shipping and among British seafarers ashore in Britain. *Int. Marit. Health* **2010**, *62*, 107–116. [PubMed]
4. Grappasonni, I.; Petrelli, F.; Amenta, F. Deaths on board ships assisted by the Centro Internazionale Radio Medico in the last 25 years. *Travel Med. Infect. Dis.* **2012**, *10*, 186–191. [CrossRef] [PubMed]
5. Jaremin, B. Work-site casualties and environmental risk assessment on Polish vessels in the years 1960–1999. *Int. Marit. Health* **2005**, *56*, 17–27. [PubMed]
6. Hansen, H.L.; Ozdemir, O.; Numanoğlu, N.; Gönüllü, U.; Savaş, I.; Alper, D.; Gürses, H. Surveillance of deaths on board Danish merchant ships, 1986-93: Implications for prevention. *Occup. Environ. Med.* **1996**, *53*, 269–275. [CrossRef]
7. Nielsen, D.; Hansen, H.L.; Gardner, B.M.; Jungnickel, D. Deaths Due to Disease of Seafarers on Board Singapore Ships. *Int. Marit. Health* **2000**, *51*, 20–29. Available online: https://pubmed.ncbi.nlm.nih.gov/11214107/ (accessed on 25 March 2021).
8. Stephen, R.E. Surveillance of work related mortality among seafarers employed on board Isle of Man registered merchant ships from 1986 to 2005. *Int. Marit. Health* **2006**, *57*, 9–23.
9. Sagaro, G.G.; Dicanio, M.; Battineni, G.; Samad, M.A.; Amenta, F. 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. *BMJ Open* **2021**, *11*. [CrossRef]
10. Mahdi, S.S.; Amenta, F. Eighty years of CIRM. A journey of commitment and dedication in providing maritime medical assistance. *Int. Marit. Health* **2016**, *67*, 187–195. [CrossRef]
11. Sagaro, G.G.; Battineni, G.; Chintalapudi, N.; Di Canio, M.; Amenta, F. Telemedical assistance at sea in the time of COVID-19 pandemic. *Int. Marit. Health* **2020**, *71*, 229–236. [CrossRef] [PubMed]
12. 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*, 155–160. [CrossRef]
13. Yu, J.; Ma, Y.; Yang, S.; Pang, K.; Yu, Y.; Tao, Y.; Jin, L. Risk Factors for Cardiovascular Disease and Their Clustering among Adults in Jilin (China). *Int. J. Environ. Res. Public Health* **2015**, *13*, 70. [CrossRef]
14. Gu, D.; Gupta, A.; Muntner, P.; Hu, S.; Duan, X.; Chen, J.; Reynolds, R.F.; Whelton, P.K.; He, J. Prevalence of cardiovascular disease risk factor clustering among the adult population of China: Results from the International Collaborative Study of Cardiovascular Disease in Asia (InterAsia). *Circulation* **2005**, *112*, 658–665. [CrossRef] [PubMed]
15. Wu, J.; Cheng, X.; Qiu, L.; Xu, T.; Zhu, G.; Han, J.; Xia, L.; Qin, X.; Cheng, Q.; Liu, Q. Prevalence and Clustering of Major Cardiovascular Risk Factors in China: A Recent Cross-Sectional Survey. *Medicine* **2016**, *95*, e2712. [CrossRef]
16. Oldenburg, M.; Jensen, H.-J.; Latza, U.; Baur, X. Coronary risks among seafarers aboard German-flagged ships. *Int. Arch. Occup. Environ. Health* **2007**, *81*, 735–741. [CrossRef] [PubMed]
17. Sagaro, G.G.; Di Canio, M.; Amenta, F. Correlation between body mass index and blood pressure in seafarers. *Clin. Exp. Hypertens.* **2021**, *43*, 189–195. [CrossRef] [PubMed]
18. Baygi, F.; Jensen, O.C.; Qorbani, M.; Farshad, A.; Salehi, S.A.; Mohammadi-Nasrabadi, F.; Asayesh, H.; Shidfar, F. Prevalence and associated factors of cardio-metabolic risk factors in Iranian seafarers. *Int. Marit. Health* **2016**, *67*, 59–65. [CrossRef] [PubMed]
19. Grappasonni, I.; Scuri, S.; Petrelli, F.; Nguyen CT, T.; Sibilio, F.; Di Canio, M.; Samad, M.A.; Amenta, F. Survey on smoking habits among seafarers. *Acta Biomed. Atenei Parm.* **2019**, *90*, 489. [CrossRef]
20. Tu, M.; Jepsen, J.R. Hypertension among Danish seafarers. *Int. Marit. Health* **2016**, *67*, 196–204. [CrossRef]
21. Kirkutis, A.; Norkiene, S.; Griciene, P.; Gricius, J.; Yang, S.; Gintautas, J. Prevalence of hypertension in Lithuanian mariners. *Proc. West. Pharmacol. Soc.* **2004**, *47*, 71–75. [PubMed]
22. Hansen, H.L.; Dahl, S.; Bertelsen, B.; Brix, J. Lifestyle, nutritional status and working conditions of Danish sailors. *Travel Med. Int.* **1994**, *12*, 139–143.
23. Kivimäki, M.; Kawachi, I. Work Stress as a Risk Factor for Cardiovascular Disease. *Curr. Cardiol. Rep.* **2015**, *17*, 1–9. [CrossRef]
24. BIMCO, ICS. Manpower Report-The Global Supply and Demand for Seafarers. *Exec Summ*. June 2015. Available online: http://www.ics-shipping.org/docs/default-source/resources/safety-security-and-operations/manpower-report-2015-executive-summary.pdf?sfvrsn=16 (accessed on 23 February 2021).

25. ILO Labour Convention 2006. Health Protection and Medical Care (Seafarers) Convention, 2006 (No. 164). Available online: https://www.ilo.org/dyn/normlex/en/f?p=1000:12100:::NO:12100:P12100_INSTRUMENT_ID:312309 (accessed on 6 October 2019).
26. World Health Organization Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation (WHO Technical Report Series 894). Available online: https://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/ (accessed on 10 August 2020).
27. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2020; Available online: http://www.R-project.org/ (accessed on 25 March 2021).
28. Wickham, H.; François, R.; Henry, L.; Müller, K. dplyr: A Grammar of Data Manipulation. 2020. Available online: https://cran.r-project.org/package=dplyr (accessed on 25 March 2021).
29. Comtois, D. Summarytools: Tools to Quickly and Neatly Summarize Data. 2021. Available online: https://cran.r-project.org/package=summarytools (accessed on 20 February 2021).
30. Sleegers, W. tidystats: Save Output of Statistical Tests. 2020. Available online: https://cran.r-project.org/package=tidystats (accessed on 20 March 2021).
31. Venables, W.N.; Ripley, B.D. *Modern Applied Statistics with with S*, 4th ed.; Springer: New York, NY, USA, 2002; Available online: https://www.stats.ox.ac.uk/pub/MASS4/ (accessed on 25 March 2021).
32. Hansen, H.L.; Hjarnoe, L.; Jepsen, J.R. Obesity continues to be a major health risk for Danish seafarers and fishermen. *Int. Marit. Health* **2011**, *62*, 98–103.
33. Hoeyer, J.A.N.L.; Hansen, H.L. Obesity among Danish Seafarers. *Int. Marit. Health* **2005**, *56*, 1–4.
34. Oldenburg, M.; Jensen, H.-J. Stress and Strain among Seafarers Related to the Occupational Groups. *Int. J. Environ. Res. Public Health* **2019**, *16*, 1153. [CrossRef]
35. Oldenburg, M.M.; Jensen, H.-J.; Latza, U.; Baur, X. Seafaring stressors aboard merchant and passenger ships. *Int. J. Public Health* **2009**, *54*, 96–105. [CrossRef] [PubMed]
36. Faghri, P. Overweight and Obesity in High Stress Workplaces. *J. Nutr. Disord. Ther.* **2013**, *3*. [CrossRef]
37. Yamada, Y.; Ishizaki, M.; Tsuritani, I. Prevention of Weight Gain and Obesity in Occupational Populations: A New Target of Health Promotion Services at Worksites. *J. Occup. Health* **2002**, *44*, 373–384. [CrossRef]
38. Gamage, A.U.; Seneviratne, R.D.A. Perceived Job Stress and Presence of Hypertension among Administrative Officers in Sri Lanka. *Asia Pac. J. Public Health* **2016**, *28* (Suppl. 1), 41S–52S. [CrossRef]
39. Owolabi, A.O.; Owolabi, M.O.; OlaOlorun, A.D.; Olofin, A. Work-related stress perception and hypertension amongst health workers of a mission hospital in Oyo State, south-western Nigeria. *Afr. J. Prim. Health Care Fam. Med.* **2012**, *4*, 7. [CrossRef]
40. Rengganis, A.D.; Rakhimullah, A.B.; Garna, H. The Correlation between Work Stress and Hypertension among Industrial Workers: A Cross-sectional Study. *IOP Conf. Ser. Earth Environ. Sci.* **2020**, *441*. [CrossRef]
41. Slišković, A.; Penezić, Z. Occupational stressors, risks and health in the seafaring population. *Rev. Psychol.* **2015**, *22*, 29–40. [CrossRef]
42. Oldenburg, M.; Baur, X.; Schlaich, C. Occupational Risks and Challenges of Seafaring. *J. Occup. Health* **2010**, *52*, 249–256. [CrossRef] [PubMed]
43. Oldenburg, M.; Jensen, H.-J.; Latza, U.; Baur, X. The risk of coronary heart disease of seafarers on vessels sailing under a German flag. *Int. Marit. Health* **2010**, *62*, 123–128. [PubMed]
44. Hanson, L.L.M.; Westerlund, H.; Goldberg, M.; Zins, M.; Vahtera, J.; Rod, N.H.; Stenholm, S.; Steptoe, A.; Kivimäki, M. Work stress, anthropometry, lung function, blood pressure, and blood-based biomarkers: A cross-sectional study of 43,593 French men and women. *Sci. Rep.* **2017**, *7*, 1–9. [CrossRef]
45. Schmidt, B.; Bosch, J.A.; Jarczok, M.N.; Herr, R.M.; Loerbroks, A.; Van Vianen, A.E.; Fischer, J.E. Effort–reward imbalance is associated with the metabolic syndrome—Findings from the Mannheim Industrial Cohort Study (MICS). *Int. J. Cardiol.* **2015**, *178*, 24–28. [CrossRef]
46. Pancić, M.; Rička-Žauhar, Z.; Blažević, M. Analysis of risk factors and assessment of exposure to coronary diseases in seamen. In Proceedings of the 8 th International Symposium on Maritime Health, Rijeka, Croatia, 8–13 May 2005.
47. Rydstedt, L.W.; Lundh, M. Work demands are related to mental health problems for older engine room officers. *Int. Marit. Health* **2012**, *63*, 176–180. [PubMed]
48. Hammar, N.; Alfredsson, L.; Smedberg, M.; Ahlbom, A. Differences in the incidence of myocardial infarction among occupational groups. *Scand. J. Work. Environ. Health* **1992**, *18*, 178–185. [CrossRef]
49. Sagaro, G.G.; Amenta, F. Past, present, and future perspectives of telemedical assistance at sea: A systematic review. *Int. Marit. Health* **2020**, *71*, 97–104. [CrossRef]
50. Sagaro, G.; Di Canio, M.; Talevil, E.; Amenta, F. Telemedicine for Pre-Employment Medical Examinations and Follow-Up Visits on Board Ships: A Narrative Review on the Feasibility. *Health* **2021**, *9*, 69. [CrossRef]
51. Mittal, M.; Battineni, G.; Goyal, L.M.; Chhetri, B.; Oberoi, S.V.; Chintalapudi, N.; Amenta, F. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. *Int. Marit. Health* **2020**, *71*, 213–214. [CrossRef] [PubMed]
52. Battineni, G.; Di Canio, M.; Chintalapudi, N.; Amenta, F.; Nittari, G. Development of physical training smartphone application to maintain fitness levels in seafarers. *Int. Marit. Health* **2019**, *70*, 180–186. [CrossRef] [PubMed]

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Article

Assessment of Awareness and Knowledge on Novel Coronavirus (COVID-19) Pandemic among Seafarers

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Abstract: *Background*: The ongoing pandemic due to the novel coronavirus (COVID-19) is becoming a serious global threat. Experts suggest that the infection can be controlled by immediate prevention measures. Sailing is one of the occupational categories more vulnerable to this virus outbreak due to the proximity of the working conditions. *Objective:* Awareness and knowledge assessments of seafarers towards the current epidemic is mandatory to understand the effectiveness and success of the infection control measures adopted by shipping companies. *Methods:* In this study, we presented an online questionnaire survey to determine the knowledge levels of COVID-19 among seafarers. The data were collected by self-reported survey, and analysis was done by the analysis of variance (ANOVA). The *t*-test was used to understand the knowledge attitude differences to COVID-19 among different occupational groups of seafarers, and the p-value $\leq$ of 0.05 was considered statistically significant. *Results:* Among 1,458 responses received, 92.82% had a college or university degree. The results reported that the mean COVID-19 knowledge score was 5.82 (standard deviation = 0.51, range 0–6), and the overall correct percentage was 97%. There was a statistically significant difference between age groups (F (4, 1453) = 5.44, $p < 0.001$) and educational groups (F (4, 1453) = 1.52, $p < 0.001$). The knowledge score was not significantly different across the educational status of the participants (F (2, 1455) = 1.52, p = 0.220). *Conclusions*: The present study highlighted good knowledge and behaviours among sailors about COVID-19. However, shipping companies need to come up with new campaigns to hold optimistic practices and suitable guidelines on ships, including cruise boats, to keep sea workers always alert and collaborative in mitigating the spread of COVID-19.

Keywords: COVID-19 spreading; online survey; awareness and knowledge; ships; seafarers

Citation: Battineni, G.; Sagaro, G.G.; Chintalapudi, N.; Di Canio, M.; Amenta, F. Assessment of Awareness and Knowledge on Novel Coronavirus (COVID-19) Pandemic among Seafarers. *Healthcare* **2021**, *9*, 120. https://doi.org/10.3390/healthcare9020120

Academic Editors: Manoj Sharma, Kavita Batra and Tao-Hsin Tung

Received: 21 December 2020

Accepted: 19 January 2021

Published: 25 January 2021

1. Introduction

The novel coronavirus disease, or COVID-19, was first identified in December 2019 at a Wuhan wet market in China and then constantly spread all over the world at a rapid pace [1]. As of 5 January 2021, more than 85 million cases have been reported, including 1.86 million deaths [2]. In many cases, COVID-19 develops mild-to-moderate symptoms. In some cases, it might cause severe sickness, including pneumonia and, consequently, death. A person who is infected by the virus usually takes five to seven days to develop symptoms, and it can extend up to 14 days [3].

Currently, many European countries like Italy, France, Germany, and others have been exposed to the second wave of the COVID-19 pandemic [4]. These countries were severely hit by the first wave of pandemic during the spring, which was followed by the second wave during late summer and autumn. Epidemic data present the virus characteristics, and its effects are varied between these two periods. The symptoms like pneumonia, dyspnea, fever, cough, chronic neurological diseases, and type 2 diabetes mellitus are often found in both waves. In severe cases, the symptoms usually get worse gradually after the initial appearance. To slow down the spreading of the virus and reduce its effects, governments around the world have made travel restrictions and closed their country's borders [5]. Various ports and air terminals are closed, ships' entries are denied, and all planes grounded.

Due to the limited medical resources, natural exposure to new environments and crowded, enclosed areas make the high risk of the present novel pandemic spread among many cruise ships [6]. On 4 February 2020, the UK-registered ship named the Diamond Princess was exposed to a large outbreak of COVID-19, and this was quarantined for about one month at Yokohama, Japan. More than 700 individuals were infected, including 14 deaths [7]. Over 40 cruise ships have confirmed positive cases of COVID-19 infection onboard, and port authorities and governments are advising people to avoid travelling on cruise ships and restraining ships from docking [8]. Besides, many maritime transport lines have been suspended to prevent the epidemic spread [9].

Seafarers are the unsung heroes of this pandemic, because over 90% of the world trade, including medical goods, raw materials, essential foods, and manufactured goods, depends on them [10]. Based on a report published by the International Maritime Organization (IMO), seafarers are collateral victims of this pandemic emergency, as travel limitations have left a huge number of them abandoned on boats or unfit to join ships [11]. Moreover, commercial fishing is a main source of the world's food. Several sailors are ready for stretched out work timeframes; to maintain a strategic distance from becoming infected, crewmembers need to change all the time, and this includes nearly 100,000 sailors every month [12,13].

The COVID-19 pandemic has introduced phenomenal circumstances around the world. The worldwide health authorities have been focused on controlling the disease by mitigating actions to limit the fast-spreading. Currently, two vaccines—namely, Pfizer-BioNtech and Moderna's—are authorized and recommended to prevent COVID-19; additionally, the presence of more than 50 COVID-19 vaccines are in trials, yet the world is looking for safe and effective ones [14]. Of the problems caused by the COVID-19 pandemic, around 90,000 sailors are now stuck on cruise ships without passengers [15]. Since the ship is a closed environment, there is a high chance of being infected. After being at sea for at least 14 days, and if no crewmember shows the symptoms of the COVID-19 illness, then a ship can be considered as virus-free and, eventually, safe.

The recent literature on COVID-19 highlights scientific knowledge or epidemic projections, especially in the public health environment [16]. Outcomes integrated with scientific knowledge tend to identify the key safety-related issues. Apart from the clinical and healthcare aspects like the safety of medical doctors, social and occupational safety, and, in particular, mental health, they have gained large attention from the COVID-19 scientific community [17]. The individuals living in closed environments like ships should have basic knowledge when addressing key social issues, including an urgent need to understand and believe the science about the COVID-19 pandemic that is shattering the present world.

This study presents an online cross-sectional survey designed to understand seafarers' behaviour and knowledge during COVID-19. A similar study was conducted on USA residents during the early epidemic phase to evaluate their knowledge levels and behavioural characteristics [18]. This study is among one of the first attempts to measure the knowledge on COVID-19 among crew members of merchant ships addressing requests for telemedical advice to the Centro Internazionale Radio Medico (C.I.R.M., International Radio Medical Centre).

2. Methods

2.1. Participants

The current cross-sectional investigation enlisted a sample of seafarers from the C.I.R.M. [19]. With more than 100,000 seafarers assisted onboard ships, the C.I.R.M. is the maritime telemedical centre with the largest experience of medical assistance to sailing seafarers. It was established in 1935 to give free radio medical advice to ships of all nationalities navigating in international waters. The C.I.R.M. is the Italian Telemedical Maritime Assistance Service (TMAS). The online questionnaire was delivered to 5000 seafarers, and 1458 (about 30%) agreed to provide consent to participate in this survey. We assumed that the participants that did not show interest in this study was due to a lack of internet onboard, staying with family because of fear caused by COVID-19, or a low-level knowledge of English.

2.2. Survey

The questionnaire included in the survey was refined by phrase changing, the possibility of adding new questions, and modifications of other research studies that provide extensive knowledge on the COVID-19 epidemic. Two C.I.R.M. doctors thoroughly reviewed the final questionnaire to make sure each item of the survey was clearly understood. The final questionnaire consisted of 25 questions and was distributed through a Google Form link.

The survey was organized into three sections: demographic characteristics, including age, rank onboard, members onboard, and educational status, etc. (5 items); personal characteristics (14 items); and the knowledge questionnaire had 6 questions regarding clinical presentation (2 questions), COVID-19 transmission routes (2 questions), and prevention and control (2 questions). Moreover, the questionnaire was adapted from previous studies on COVID-19 knowledge [18,20]. These questions were answered by correct and incorrect options. As a result, a correct answer was assigned "1", and an incorrect answer was assigned "0".

Before starting the survey, seafarers read an informed consent explanation that portrayed that cooperation was deliberate and that they could stop whenever. By tapping on a "next" button, members were considered as agreeing to finish the online questionnaire. The survey consisted of closed-ended questions, of which six permitted the seafarers to have the chance to give further details if the "other" alternative was chosen from the multiple-choice questions. The closed-ended questionnaire consisted of categorical, dichotomous, multiple-choice, and Likert-type questions on five-point rating scales. At the end of the questionnaire, we requested the participants provide final feedback regarding their participation in the study.

2.3. Reliability and Validity of Responses

The main objective of any questionnaire is to gather relevant information most reliably and validly. These factors are commonly associated with the conduction and selection of valid research instruments. As mentioned, this was a study related to onboard behavioural characteristics of seafarers, and we adopted the face validity method that was done by an analysis of the data using Cohen's Kappa Index (CKI). A kappa value that was greater than 0.6 was accepted as a valid question [21]. The items in the knowledge questionnaire were further validated with the CKI scale.

2.4. Statistical Analysis

Demographic variables such as age, rank, and educational status were done using frequency analysis. Frequencies of correct answers to knowledge questions were determined. A one-way analysis of variance (ANOVA) was used to determine the differences in the mean knowledge scores between the age groups, rank groups, and educational status. The *t*-test was used to understand the knowledge attitude differences to COVID-19 among different occupational groups of seafarers, and a *p*-value of ≤ 0.05 was considered statistically significant. Statistical analysis was carried out by IBM SPSS v.26 (Armonk, New York, NY, USA).

2.5. Ethical Approval

The review board members and the Ethics Committee of C.I.R.M. approved this study. The checklist for research ethics during the COVID pandemic was adopted from the UK research integrity office (UKRIO) guidelines [22]. This study was reviewed and approved by the C.I.R.M. Research Ethics Committee (ESI/2020/017). All participants provided consent by responding to a yes/no inquiry toward the beginning of the survey before they responded to the first question.

3. Results

Table 1 includes the participants' basic demographic characteristics: age group, rank onboard, and educational status. Table 2 presents nine questionnaires that were administered to measure the awareness about COVID-19, including clinical characteristics, transmission, prevention, and control. Among the total number of the respondents, the majority (97.87%) of them reported that they are aware of the novel coronavirus outbreak. Of the respondents that reported, 93.63% said that they were never infected by the new coronavirus, and 88.73% of the respondents reported that none of the people in their immediate social environments were infected.

Table 1. Participant demographic and awareness characteristics.

Demographic Characteristics	N	%
Gender		
Male	1241	85.11
Female	217	14.89
Age (Years)		
<20	21	1.4
20–30	332	22.8
30–40	431	29.6
40–50	571	39.2
>60	103	7.1
Education		
Primary education	44	1.01
College/University education	1237	92.82
Secondary School education	177	6.17
Rank on board		
Deck Officers	579	39.72
Deck Rating	281	19.24
Engine Officers	268	18.35
Engine Rating	220	15.11
Galley	111	7.58

Regarding behaviours, 42.57% of the participants reported that they were moving with other staff onboard, and just 0.22% of participants used a bed previously used by someone who got infected. Most seafarers (98.4%) provided a correct response on the transmission of the novel coronavirus. Regarding mental health status, 33 (2.24%) seafarers reported feeling lonely, 862 (59.13%) seafarers reported feeling well, 395 (27.10%) seafarers reported missing family/friends and 168 (11.53%) seafarers reported feeling overstressed.

The correct answers to knowledge questions ranged from 91.8% to 99.4% (Table 3). The mean COVID-19 knowledge score was 5.82 (standard deviation = 0.51, range 0–6), and the overall correct percentage was 97%. Most of the seafarers (99.4%) were aware of the COVID-19 clinical symptoms, and 95.7% realized that all infected individuals did not develop into severe cases. Viral infections are highly contagious among the people who live nearby and spread by respiratory droplets. Most respondents (97.3%) were aware that COVID-19 can be caused by human transmission when infected persons cough or sneeze.

Table 2. Awareness on COVID-19 onboard.

Q1. Are you aware of the novel coronavirus outbreak?		
Heard from Others	13	0.90
No	18	1.23
Yes	1427	97.87
Q2. Are you or have you been infected with the novel coronavirus?		
Do not know	86	5.92
No	1365	93.63
Yes, confirmed	7	0.45
Q3. Do you know people in your immediate social environment who are or have been infected with the novel coronavirus?		
Do not know	106	7.25
No	1294	88.73
Yes, confirmed	42	2.91
Yes, not confirmed	16	1.11
Q4. Are you closely moving with other staff onboard?		
No	196	13.41
Sometimes, I cannot avoid	642	44.02
Yes	621	42.57
Q5. Was your travel history associated with infected countries in the last two months?		
Maybe	52	3.58
No	414	28.41
Yes	992	68.01
Q6. Have you used a bed previously used by someone who got infected by coronavirus?		
May be	18	1.23
No	1436	98.5
Yes	3	0.22
Q7. Which of the following is correct about the transmission of the novel coronavirus?		
Do not know	11	0.78
The novel coronavirus is not transmissible	3	0.22
The novel coronavirus is transmissible from person to person.	1435	98.44
The novel coronavirus is transmitted by animals to humans only	8	0.56
Q8. Are your handwashing for at least 20 s?		
Yes	1366	93.68
No	92	6.32
Q9. How is your mental health during these periods		
Missing family and friends	395	27.1
Feeling lonely	33	2.24
More often getting stress	168	11.53
Feeling well	862	59.13

Table 3. Frequency of correct answers to the knowledge questions. CKI: Cohen's Kappa Index.

Knowledge Questions	N (Correct%)	CKI
KQ1: The main clinical symptoms of COVID-19 are fever, fatigue, shortness of breath, and dry cough.	1449 (99.4)	0.7
KQ2: Not all persons with COVID-19 will develop into severe cases. Those who are older and have chronic illnesses such as diabetes, heart diseases, cancer, and chronic kidney diseases are more likely to have severe cases.	1395 (95.7)	0.6
KQ3: The COVID-19 virus spreads via respiratory droplets of infected individuals.	1418 (97.3)	0.8
KQ4: By wearing masks onboard, it is possible to control the speed of the virus spreading.	1338 (91.8)	0.9
KQ5: Isolations and treatment of people who are infected with COVID-19 are effective ways to reduce the spread of the virus.	1443 (99)	0.8
KQ6: People who have contact with someone infected with the COVID-19 virus should be immediately isolated. In general, the observation period is 14 days.	1448 (99.3)	0.7

Based on the guidelines provided by the World Health Organization (WHO), it is evident that wearing facemasks only can help prevent becoming infected with the virus [23]. In this study, 92% of participants agreed that spreading of the virus can be controlled by wearing masks onboard; 99% mentioned that treatment and isolation are promising ways to reduce the virus transmission, and 99.3% provided the correct response on the incubation period of COVID-19. These findings appreciate the well-known knowledge of emphasizing maintaining onboard social distancing to control further infections. There was a statistically significant difference between the age groups ($F (4, 1453) = 5.44$, $p < 0.001$) and rank groups ($F (4, 1453) = 32.18$, $p < 0.001$), as determined by one-way ANOVA. The knowledge scores were not significantly different across the educational statuses of the participants ($F (2, 1455) = 1.52$, $p = 0.220$) (Table 4).

Table 4. Background characteristics of seafarers and knowledge scores of COVID-19 by age, rank, and educational status.

Demographic Characteristics				
	N (%)	Knowledge (Mean + S.D)	F-Test	*p*-Value
Age Group				
<20 Years	21 (1.44)	5.43 + 0.81		
20–30 Years	312 (21.4)	5.76 + 0.56		
31–40 Years	440 (30.2)	5.84 + 0.49	5.44	<0.001
41–50 Years	573 (39.3)	5.86 + 0.44		
>51 Years	112 (7.7)	5.79 + 0.60		
Rank category				
Deck officer	579 (39.7)	5.98 + 0.12		
Engine officer	268 (18.4)	5.76 + 0.57		
Deck Rating	281 (19.3)	5.73 + 0.61	32.18	0.220
Engine Rating	220 (15)	5.74 + 0.60		
Galley	110 (7.5)	5.51 + 0.76		
Educational status				
Primary school	44 (3)	5.70 + 0.55		
Secondary school	177 (12)	5.85 + 0.45	1.52	<0.001
College/University	1237 (85)	5.82 + 0.52		

The data on the knowledge of daily preventive measures by seafarers are summarized in Figure 1. As shown, few respondents had limited knowledge due to a low educational status. Among the total respondents, 1412 (97%) indicated that they avoid face touching, 1347 (92.38%) anticipated covering their faces when they sneezed or coughed, and 986 (68%) chose disinfectants for cleaning their hands when soap was not available. Moreover, 1226 (84%) followed social distancing onboard, and 1128 (77.3%) wore masks while moving onboard. To increase their immune systems, 801 (55%) preferred to do exercise, 481 (33%) habitually drank ginger tea, and only 47 (3%) were interested in using antibiotics.

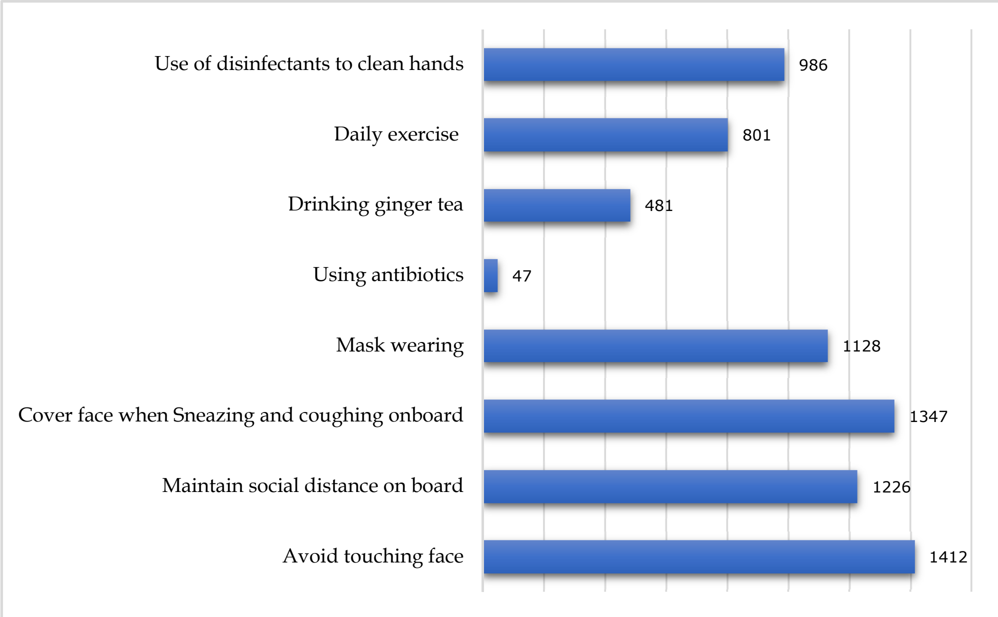

Figure 1. Onboard individual prevention measures by seafarers.

4. Discussion

Many studies were found related to the knowledge, attitudes, and practices (KAP) concerning the COVID-19 outbreak [24–27], but the literature search did not identify any works on seafarer COVID-19 knowledge assessments. Due to this, we developed a tool to investigate COVID-19 knowledge, including behavioural characteristics and the necessity of onboard health measures.

4.1. Personal Awareness

The personal awareness questionnaire was created to understand the factors that decide virus transmission onboard and further classified into three constructs, such as environment hygiene, socio-travel characteristics, and poor health literacy. These, indeed, are considered the four factors that demonstrate seafarers' knowledge of COVID-19 transmission.

Early data on public health practices embraced to forestall the spread of COVID-19 might help control the virus transmission; it is also necessary to publicize knowledge of the psychological characteristics of the stigma and social discrimination (SAD) in pandemic realities [28,29]. Recent evidence confirmed that the COVID-19 disease is transmitted by either physical contact or respiratory droplets of an infected person [30]. Moreover, contact transmission can be possible when an infected individual onboard touch their nose, eye, or mouth mucosa, and the virus can also be transferred from one surface to another by contaminated hands. Due to this, hand hygiene is mandatory to prevent the COVID-19 virus spread. In this study, 97.3% of seafarers agreed with the concept that the virus spread was caused by respiratory droplets of contaminated individuals. Rubbing hands with alcohol-based soap for at least 20 s is an effective approach to neutralize viruses like corona because of an oily surface membrane that is decomposed by soap [31]. The highest number (93.68%) of seafarers mentioned that they do 20-s hand washes with alcoholic soaps.

Travel behaviour is another important characteristic of the spread of COVID in any working culture. Due to global trading during the pandemic, the percentage of the population engaged in international travel is higher in Western countries like Europe, the USA, and others. In the present study, 992 (68.01%) seafarers mentioned that they travelled to infected nations during April and May 2020. Moreover, COVID-19 can largely spread among the populations of infected cases in the next social environment [32]. Respondents mentioned that about 58 (4%) people were suspected of contracting COVID-19 during working conditions, and 42 members were confirmed as infected. Maintaining social distancing with other employees also prevents the virus spread, but sometimes, it is hard to avoid staff movements in closed environments. 40% of participants mentioned that they are aware of social distancing but are unable to escape from unexpected situations, and 42.57% are closely moving with others. Maintain isolation onboard for people who are confirmed or suspected by COVID-19. A person in isolation is not supposed to leave the place and keep away from the public on the ship. Others should also be aware of not sharing the belongings of infected people. Most of the seafarers (98.5%) did not intend to use the bed of a COVID-19-infected person.

Poor health literacy about COVID-19 is an underrated global public health issue. Significant health literacy already seems like an important tool for the prevention of non-communicable diseases like an ongoing epidemic [33]. In the present research, 97.87% of members said that they were aware of the present virus outbreak, and 98.44% of respondents were well informed about it being caused by human transmission.

4.2. Seafarers' COVID-19 Knowledge

COVID-19 is an ongoing pandemic with serious threats to public health [34]. Since most of the vaccines are under trails, preventive measures are the only solution to control it, and therefore, everyone should have minimum knowledge on this novel virus. Attempts to change behaviours are basic in limiting the easy transmission of diseases like COVID-19, and it is unclear whether people knew about the risk of disease and adjusted their behaviours during the early times of the pandemic [35]. Due to its highly contagious nature in enclosed areas, seafarers' behaviours on a ship are probably the main factor in deciding the spread of a COVID-19 epidemic. Their behaviours are affected by their perceptions and individual knowledge.

The study outcomes indicated that most of the seafarers were knowledgeable, and respondents achieved a mean of 97% in the knowledge questionnaire. This value is higher than other audiences, like the general public and health workers, which ranged from 62% to 81.4% [24–27]. In this study, the 92.82% rate of correct answers is probably related to the cultural background of the respondents that mostly had a college or university education. This is also due to the time that the questionnaire distribution happened during the virus outbreak. During this time, seafarers already gained some knowledge regarding COVID-19 prevention and transmission causes via the internet, media platforms, or colleague discussions. The close associations found among educational background, age, and knowledge ($p < 0.001$) supports our claims. On the other hand, the knowledge of daily preventive measures by seafarers was much appreciable. Very few respondents had limited knowledge due to a low educational status.

In terms of the seafarers' behavioural characteristics on ships, the respondents presented a positive and encouraging approach towards COVID-19. About 96% agreed that the virus does not develop into a serious illness unless in the presence of other chronic diseases. These inspirational mentalities and high trust in the control of COVID-19 can be clarified by the marine industries' phenomenal activities and brief reaction times for taking tough control and prudent steps against COVID-19 to defend ship workers and guarantee their better health. These measures include isolation, avoid travelling on other ships, regulations on mask-wearing, and sanitization of the workplace regularly.

4.3. Study Strengths and Limitations

This is probably the first study that investigated the awareness and knowledge regarding COVID-19 among the seafarer population. The data collection involved nearly

30 shipping companies, including more than 1,000 ship workers. The preliminary results encourage ship authorities to provide explicit guidelines and plan preventive actions to avoid the future spread of the virus at ship working places. Despite the promising knowledge outcomes, the present study had some limitations. Since the data analysis was conducted with the help of a self-reported questionnaire, there is a chance of biased outcomes. Forthcoming works must use administrative questionnaire data to overcome this issue. Besides, community-based sample (like seafarers) studies cannot provide as much evidence on the severity of pandemics as the data collected through participants of author networks. On the other hand, the highest number of participants were from European shipping companies, and future research needs to include worldwide merchant ship members.

5. Conclusions

The current global pandemic caused by the COVID-19 disease is creating awful situations for both seafarers and marine industries. By maintaining a close relationship between shipping companies, flag and port states, and others, maritime service providers can protect seafarers' health and, simultaneously, the public [36]. Certain web-based interventions like online questionnaires can enhance the individual knowledge of seafarers by informing, educating, reminding, and monitoring to fight against the ongoing epidemic. Hygiene conditions, waste management, and room sanitation onboard are mandatory to protect an individual's health during virus outbreaks, including COVID-19. Guaranteeing continuous handwashing and practices in waste management at working stations will help to control the person-to-person transmission of the virus. This study was conducted during the COVID-19 first wave, and we would like to recontact the participants to evaluate their behaviours at the surge of the present second wave. Alternatively, telemedicine represents the most realistic approach to provide medical assistance at sea. The same technologies respecting legal and ethical standards [37] should be considered for providing health education of seafarers.

Author Contributions: Conceptualization, G.B. and G.G.S.; methodology, G.B.; software, G.B.; validation, G.B., G.G.S. and M.D.C.; formal analysis, G.B.; investigation, G.B.; resources, G.B.; data curation, G.B., N.C. and G.G.S.; writing—original draft preparation, G.B. and F.A.; writing—review and editing, G.B.; visualization, G.B. and M.D.C.; supervision, F.A.; project administration, F.A.; funding acquisition, F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by the ITF Trust grant No. 1508/2020 to the Centro Internationale Radio Medico (C.I.R.M.). Institutional funding of the University of Camerino, Italy, supported this work. G.B., G.G.S., and N.C. were recipients of PhD bursaries from the University of Camerino.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of UK research integrity office (UKRIO) during COVID-19 by the Ethics Committee of C.I.R.M.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The COVID-19 data were extracted from the public domain data repository of the Centre for Systems Science and Engineering (CSSE) at John Hopkins University.

Acknowledgments: The collaboration of the Italian Shipowners associations Confitarma and Assarmatori in promoting participation in the survey is gratefully acknowledged. The authors are indebted to A Saturnino (C.I.R.M., Rome) for his support in the distribution of the questionnaire.

Conflicts of Interest: No author does not have any conflict of interest.

References

1. Huang, C.; Wang, Y.; Li, X.; Ren, L.; Zhao, J.; Hu, Y.; Zhang, L.; Fan, G.; Xu, J.; Gu, X.; et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* **2020**, *395*, 497–506. [CrossRef]
2. COVID-19 Map—Johns Hopkins Coronavirus Resource Center. Available online: https://coronavirus.jhu.edu/map.html (accessed on 5 January 2021).

3. Battineni, G.; Chintalapudi, N.; Amenta, F. AI Chatbot Design during an Epidemic like the Novel Coronavirus. *Healthcare* **2020**, *8*, 154. [CrossRef]
4. Bontempi, E. The europe second wave of COVID-19 infection and the Italy "strange" situation. *Environ. Res.* **2020**, 110476. [CrossRef] [PubMed]
5. Chintalapudi, N.; Battineni, G.; Amenta, F. COVID-19 virus outbreak forecasting of registered and recovered cases after sixty day lockdown in Italy: A data driven model approach. *J. Microbiol. Immunol. Infect.* **2020**, *53*, 396–403. [CrossRef] [PubMed]
6. Sawano, T.; Ozaki, A.; Rodriguez-Morales, A.J.; Tanimoto, T.; Sah, R. Limiting spread of COVID-19 from cruise ships: Lessons to be learnt from Japan. *QJM Int. J. Med.* **2020**, *113*, 309–310. [CrossRef] [PubMed]
7. Mizumoto, K.; Kagaya, K.; Zarebski, A.; Chowell, G. Estimating the asymptomatic proportion of coronavirus disease 2019 (COVID-19) cases on board the Diamond Princess cruise ship, Yokohama, Japan, 2020. *Eurosurveillance* **2020**, *25*, 2000180. [CrossRef]
8. Malone, J.D. USS Theodore Roosevelt, COVID-19, and Ships: Lessons Learned. *JAMA Netw. Open* **2020**, *3*, e2022095. [CrossRef]
9. Fernandes, E.G.; Santos, J.D.S.; Sato, H.K. Outbreak investigation in cargo ship in times of COVID-19 crisis, Port of Santos, Brazil. *Rev. Saúde Pública* **2020**, *54*, 34. [CrossRef]
10. International Labour Standards on Seafarers. Available online: https://www.ilo.org/global/standards/subjects-covered-by-international-labour-standards/seafarers/lang--en/index.htm (accessed on 8 January 2021).
11. International Maritime Orgnization Home Page. Available online: https://www.imo.org/en (accessed on 6 January 2021).
12. Battineni, G.; Amenta, F. Designing of an Expert system for the management of Seafarer's health. *Digit. Health* **2020**, *6*. [CrossRef]
13. Sagaro, G.G.; Battineni, G.; Chintalapudi, N.; Di Canio, M.; Amenta, F. Telemedical assistance at sea in the time of COVID-19 pandemic. *Int. Marit. Health* **2020**, *71*, 229–236. [CrossRef]
14. COVID-19 Vaccines. Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines (accessed on 5 January 2021).
15. Coronavirus Hits More Cruise Ships, Leaving Vessels Stuck at Sea—WSJ. Available online: https://www.wsj.com/articles/coronavirus-hits-more-cruise-ships-leaving-vessels-stuck-at-sea-11584373335 (accessed on 5 January 2021).
16. Battineni, G.; Chintalapudi, N.; Amenta, F. SARS-CoV-2 epidemic calculation in Italy by SEIR compartmental models. *Appl. Comput. Inform.* **2020**. [CrossRef]
17. Haghani, M.; Bliemer, M.C.; Goerlandt, F.; Li, J. The scientific literature on Coronaviruses, COVID-19 and its associated safety-related research dimensions: A scientometric analysis and scoping review. *Saf. Sci.* **2020**, *129*, 104806. [CrossRef] [PubMed]
18. Clements, J.M. Knowledge and Behaviors toward COVID-19 among US Residents during the Early Days of the Pandemic: Cross-Sectional Online Questionnaire. *J. Med. Internet Res.* **2020**, *6*, e19161. [CrossRef] [PubMed]
19. Battineni, G.; Sagaro, G.G.; Chintalapudi, N.; Amenta, F. Conceptual Framework and Designing for a Seafarers' Health Observatory (SHO) Based on the Centro Internazionale Radio Medico (C.I.R.M.) Data Repository. *Sci. World J.* **2020**, *2020*, 1–5. [CrossRef] [PubMed]
20. Ferdous, M.Z.; Islam, S.; Sikder, T.; Mosaddek, A.S.M.; Zegarra-Valdivia, J.A.; Gozal, D. Knowledge, attitude, and practice regarding COVID-19 outbreak in Bangladesh: An online-based cross-sectional study. *PLoS ONE* **2020**, *15*, e0239254. [CrossRef] [PubMed]
21. Taherdoost, H. Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. *SSRN Electron. J.* **2018**. [CrossRef]
22. UKRIO. Checklist during COVID-19. Available online: https://ukrio.org/publications/recommended-checklist-during-covid-19/ (accessed on 10 January 2021).
23. WHO. Mask Use in the Context of COVID-19, Who, No. December 2020, pp. 1–10. Available online: https://www.who.int/publications/i/item/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak (accessed on 1 January 2021).
24. Zhong, B.L.; Luo, W.; Li, H.M.; Zhang, Q.Q.; Liu, X.G.; Li, W.T.; Li, Y. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: A quick online cross-sectional survey. *Int. J. Biol. Sci.* **2020**, *16*, 1745–1752. [CrossRef]
25. Al-Hanawi, M.K.; Angawi, K.; Alshareef, N.; Qattan, A.M.N.; Helmy, H.Z.; Abudawood, Y.; AlQurashi, M.; Kattan, W.M.; Kadasah, N.A.; Chirwa, G.C.; et al. Knowledge, Attitude and Practice Toward COVID-19 Among the Public in the Kingdom of Saudi Arabia: A Cross-Sectional Study. *Front. Public Health* **2020**, *8*, 217. [CrossRef]
26. Azlan, A.A.; Hamzah, M.R.; Sern, T.J.; Ayub, S.H.; Mohamad, E.M. Public knowledge, attitudes and practices towards COVID-19: A cross-sectional study in Malaysia. *PLoS ONE* **2020**, *15*, e0233668. [CrossRef]
27. Akalu, Y.; Ayelign, B.; Molla, M.D. Knowledge, Attitude and Practice towards COVID-19 among Chronic Disease Patients at Addis Zemen Hospital, Northwest Ethiopia. *Infect. Drug Resist.* **2020**, *13*, 1949–1960. [CrossRef]
28. Irigoyen-Camacho, M.E.; Velazquez-Alva, M.C.; Zepeda-Zepeda, M.A.; Cabrer-Rosales, M.F.; Lazarevich, I.; Castaño-Seiquer, A. Effect of Income Level and Perception of Susceptibility and Severity of COVID-19 on Stay-at-Home Preventive Behavior in a Group of Older Adults in Mexico City. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7418. [CrossRef] [PubMed]
29. Baldassarre, A.; Giorgi, G.; Alessio, F.; Lulli, L.G.; Arcangeli, G.; Mucci, N. Stigma and Discrimination (SAD) at the Time of the SARS-CoV-2 Pandemic. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6341. [CrossRef] [PubMed]

30. Dhand, R.; Li, J. Coughs and Sneezes: Their Role in Transmission of Respiratory Viral Infections, Including SARS-CoV-2. *Am. J. Respir. Crit. Care Med.* **2020**, *202*, 651–659. [CrossRef] [PubMed]
31. WHO. *Updated WHO Recommendations for International Traffic in Relation to COVID-19 Outbreak, COVID-19 Travel Advice*; WHO: Geneva, Switzerland, 2020.
32. Chintalapudi, N.; Battineni, G.; Sagaro, G.G.; Amenta, F. COVID-19 outbreak reproduction number estimations and forecasting in Marche, Italy. *Int. J. Infect. Dis.* **2020**, *96*, 327–333. [CrossRef]
33. Nguyen, H.C.; Nguyen, M.H.; Do, B.N.; Tran, C.Q.; Nguyen, T.T.P.; Pham, K.M.; Pham, L.V.; Tran, K.V.; Duong, T.T.; Tran, T.V.; et al. People with Suspected COVID-19 Symptoms Were More Likely Depressed and Had Lower Health-Related Quality of Life: The Potential Benefit of Health Literacy. *J. Clin. Med.* **2020**, *9*, 965. [CrossRef]
34. Dryhurst, S.; Schneider, C.R.; Kerr, J.R.; Freeman, A.L.J.; Recchia, G.; Van Der Bles, A.M.; Spiegelhalter, D.; Van Der Linden, S. Risk perceptions of COVID-19 around the world. *J. Risk Res.* **2020**, *23*, 994–1006. [CrossRef]
35. Wise, T.; Zbozinek, T.D.; Michelini, G.; Hagan, C.C.; Mobbs, D. Changes in risk perception and self-reported protective behaviour during the first week of the COVID-19 pandemic in the United States: COVID-19 risk perception and behavior. *R. Soc. Open Sci.* **2020**. [CrossRef]
36. Ipsema | Facile.it. Available online: https://www.facile.it/assicurazioni/glossario/ipsema.html (accessed on 10 January 2021).
37. Nittari, G.; Khuman, R.; Baldoni, S.; Pallotta, G.; Battineni, G.; Sirignano, A.; Amenta, F.; Ricci, G. Telemedicine Practice: Review of the Current Ethical and Legal Challenges. *Telemed. J. E-Health* **2020**, *26*, 1427–1437. [CrossRef]

CLINICAL AND EXPERIMENTAL HYPERTENSION
https://doi.org/10.1080/10641963.2020.1836193

Correlation between body mass index and blood pressure in seafarers

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ABSTRACT

Background: High blood pressure is a serious medical condition that significantly increases the risk of cardiovascular disease. Although overweight and high blood pressure are frequent consequences for the health of life at sea, there is a paucity of information on the contribution of body mass index (BMI) to high blood pressure (HBP) in seafarers.
Objective: The present study was aimed to examine the relationship between BMI and blood pressure and to analyze further BMI as a risk factor for high blood pressure through a modeling approach.
Materials and Methods: A retrospective analysis was performed on 603 seafarers' medical examination records. The seafarer's blood pressure and BMI were recorded and interpreted according to the WHO criteria. Pearson product-moment correlation was examined to determine the association between BMI and blood pressure. Multinomial logistic regression models were performed to estimate the strength of association between the BMI and the HBP.
Results: Out of a total of 603 seafarers under study, 44.4% and 55.6% were officers and non-officers, respectively. Mean SBP, DBP, and BMI were significantly higher among non-officers than officers. BMI was positively correlated ($p < .01$) with both SBP (r = 0.336) and DBP (r = 0.344). About 39% and 16.6% of the study subjects were prehypertension and hypertensive, respectively. The risk of prehypertension and hypertension was higher in individuals who were overweight and obese.
Conclusions: Mean blood pressure levels increase parallel to the rise of BMI. Thus, emphasis should be given on a weight management program in relation to the prevention and control of high blood pressure.

ARTICLE HISTORY
Received 8 September 2020
Revised 1 October 2020
Accepted 5 October 2020

KEYWORDS
Body mass index; blood pressure; seafarers; overweight; obesity; hypertension

Introduction

Globally, in 2019, approximately 1.13 billion people have high blood pressure. Of these, nearly 67% are living in low- and middle-income countries(1). In 2015, one in four men and one in five women had hypertension(1). Increased blood pressure is a serious medical condition that significantly increases the risk of cardiovascular diseases (CVD). Furthermore, it is the preventable risk factor for premature deaths worldwide(1). About 54% of strokes and 47% of coronary heart diseases are attributable to high blood pressure (2). Over 1.9 billion adults aged 18 and over were overweight in 2019, and among them, around 650 million adults were obese (3). Increased body mass index (BMI) is the main risk factor for CVD, diabetes, especially type 2, musculoskeletal disorders, and other chronic diseases such as certain cancers (3). Furthermore, in 2015, elevated BMI values were responsible for over four million deaths worldwide, and of these numbers, approximately 66% were attributed to CVD (4).

Seafaring is a dangerous occupation (5), characterized by physical and psychological stressors, sudden climate changes (6). Workers at sea have high rates of mortality, illness, and injury when compared to the general population (7). CVD is the leading cause of death onboard ships (8–10). Seafarers working and living conditions are characterized by long working hours, a short average of sleep times, night shift works, prolonged isolation from family, and work-related stress (5, 11–14). Furthermore, behavioral risk factors such as smoking, an unhealthy diet, physical inactivity, excessive alcohol consumption are highly prevalent among seafarers (15,16). This heavy consumption of alcohol and smoking could be due to hectic activity and lack of leisure-time onboard.

Several studies have found that nutritional factors, shift work, sleep patterns, work-related stress, and fatigue may play a critical role in increasing coronary heart diseases (CHD) and other metabolic syndromes such as central obesity, glucose intolerance, and hypertension (16–19). Also, another work reported that work-related stress increased by over 50% of CHD risk (20). High blood pressure (hypertension) remains the most important and well-documented modifiable risk factor for CVD, such as stroke and coronary heart disease (21). In contrast, risk factors such as smoking, lack of exercise, alcohol abuse, increased BMI value, and an unhealthy diet can play a vital role in the cause of arterial hypertension (22,23). Health consequences such as high BMI, diabetes, and hypertension (HBP) are frequent consequences of life at sea (24–26).

In general, there are several studies on the relationship between body mass index (BMI) and blood pressure (BP) in general populations (27–31). The positive association between BMI and BP is well documented (27,29, 32–35). However, this relationship is not studied in seafarers. Some studies have reported the prevalence of high blood pressure and overweight/

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obesity among seafarers. It has been reported that the occurrence of hypertension was 49% among Lithuanian mariners (24), 44.7% among Danish seafarers (25), 49.7% among seafarers in German-flagged ships (16), 19.2% among Iranian seafarers (36). Furthermore, the prevalence of overweight and obese was 50% and 20% among Danish seafarers (37), 42.5% and 8.6% among Iranian seafarers (36), and 40.8% and 11.2% among seafarers in Italian Flagged vessels (38), respectively.

The aims of this study are 1) to examine the relationship between Body mass index (BMI) and blood pressure in seafarers; 2) to analyze further BMI as a risk factor for high blood pressure (HBP) in seafarers through a modeling approach.

Materials and methods

A retrospective study was carried out on 603 seafarer's medical examination records. In Italian flagships, all seafarers are required to undergo medical examination two times per year (every 6 months) due to the rigorous demand for work onboard ships. The medical examination was conducted by the International Radio Medical Center (C.I.R.M.) physicians and other trained health professionals. C.I.R.M. is an Italian Telemedical Maritime Assistance Service (TMAS) Center and is the organization with the largest experience worldwide in terms of the number of patients assisted and various health surveillance activities performed onboard ships. During the medical examination, seafarers undergo an interview with physicians or trained health professionals, physical examination and measurements, and laboratory tests. All medical examination results are recorded in the C.I.R.M. database. For this study, we analyzed 603 seafarer's medical examination records, carried out between 2018 and 2019 on board of Italian Flagships. Data on weight, height, age, sex, rank, blood pressure value, smoking, and physical activity were extracted from the database by the authors of this study.

Blood pressure (BP), height, and body weight measurements were taken by trained health professionals and physicians. In addition to physical measurements, seafarers who are subjected to medical examinations were interviewed information about demographic data such as age, rank, and other necessary information, including smoking habits and physical activity. Physical activity is defined as seafarers involved in vigorous or moderate exercise or engaged in activities such as carrying or lifting heavy loads for at least 10 minutes continuously. The seafarer's blood pressure, as well as other measurements, were recorded and interpreted according to the WHO criteria (39). Regarding blood pressure, subjects were categorized into three groups: normal blood pressure, prehypertensive, and hypertensive. Normal blood pressure was taken as systolic blood pressure (SBP) <120 mmHg and diastolic blood pressure (DBP) <80 mmHg, whereas SBP reading of 120–139 mmHg and/or DBP value of 80–89 mmHg were classified as prehypertensive. Blood pressure values of SBP ≥140 mmHg and/or DBP ≥90 mmHg and/or self-reported use of antihypertensive medication were classified as hypertensive (39). BMI was determined as weight in kilograms (kg) divided by height in meters (m) squared [Weight (kg)/Height (m)^2]. BMI was also classified according to WHO guideline, underweight (<18.5 kg/m^2), normal body weight (18.5–24.99 kg/m^2), overweight (25–29.99 kg/m^2) and obesity (≥30 kg/m^2) (40).

Statistical analysis

Statistical analysis was carried out by using STATA software version 15. Descriptive statistics such as mean and standard deviation were analyzed to evaluate the mean value of SBP, DBP, BMI, Height, age, and the bodyweight of the participants. Chi-square and independent sample t-tests were performed to determine the differences in the distribution of categorical variables and continuous variables between rank groups. Pearson product-moment correlation was examined to determine the strength of the association between BMI and BP (SBP and DBP). ANOVA (One – way analysis of variance) was employed to determine differences in the mean value of blood pressure (both SBP and DBP) between age groups and BMI categories.

Multinomial logistic regression models were performed to determine the association between the predictor variables and the dependent variable. The dependent variable (blood pressure) was classified into three groups: normal (reference category), prehypertension, and hypertension. Hence, the multinomial regression model compared the probability in the categories of normal vs. prehypertension and normal vs. hypertension and adjusted for age. The independent variables were BMI, rank group, cigarette smoking, and physical activity. A $p < .05$ was considered statistically significant.

Results

Characteristics of the study participants

A total of 603 seafarers underwent a medical examination onboard Italian Flagships. Of these, 44.4% (268) were officers, and the remaining 335 (55.6%) were non- officers. About 28.4% of officers and 41.2% of non-officers were smoked cigarettes, and cigarette smoking levels differed significantly between the rank group (p = .001). Almost 86% (517) of the participants were engaged in any physical exercises. The mean value of height was significantly higher among officers when compared to non-officers. In contrast, average SBP, DBP, and BMI were significantly higher in non-officers than officers. Almost all (98.2%) of the participants were male, and the remaining 1.8% were female (Table 1).

Prevalence of high blood pressure

The prevalence of prehypertension (SBP: 120–139 mmHg and/or DBP: 80–89 mmHg) and hypertension (SBP > = 140 mmHg and/or DBP > = 90 mmHg) was 39% (95% CI: 35–43%) and 16.6% (95% CI: 13.7–19.8%) in individuals, respectively. Overall, high blood pressure was seen in 56% of the participants. Regarding rank distribution, prehypertension found in 34% of officers and 43% of non-officers. Also, hypertension observed in 9% of officers and 22.4% of non-officers. The differences in blood pressure levels between officers and non-

Table 1. Characteristics of the study participants (n = 603).

Characteristics	Overall	Officer	Non-officer	*P-value
Age group (years)				
≤ 30	161	85	76	0.082
31 - 40	227	96	131	
41-50	124	48	76	
≥ 51	91	39	52	
Mean age ± S.D (years)	37.37 ± 10.53	36 ± 10.2	38.22 ± 10.72	0.026
Mean Height ± S.D (cm)	174.5 ± 8.88	175.7 ± 7.88	173.54 ± 9.51	0.003
Mean Weight ± S.D (kg)	77.78 ± 11.09	77.5 ± 11.56	78.04 ± 10.69	0.514
Mean BMI (kg/m^2) ± S.D	25.55 ± 3.24	25.05 ± 3.14	25.94 ± 3.27	0.001
Mean SBP ± S.D (mmHg)	125.91 ± 10.12	123.70 ± 10.47	127.86 ± 9.48	<0.001
Mean DBP ± S.D (mmHg)	83.45 ± 7.48	82.41 ± 6.09	84.36 ± 8.32	0.001
Currently, smoking any tobacco products				
Yes	214	76	138	0.001
No	389	192	197	
Engaged in any exercise				
Yes	517	224	293	0.176
No	86	44	42	

S.D = standard deviation, kg = kilogram, cm = centimeters, mmHg = millimeter of mercury.
SBP = systolic blood pressure, DBP = diastolic blood pressure, m = meters, *P < 0.05 comparing non-officers vs. officers.

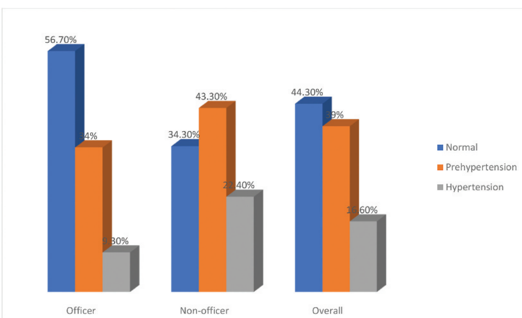

Figure 1. Percentage distribution of blood pressure levels among seafarers by rank group.

officers were statistically significant[$X^2(2) = 35.48$, $P < .001$] (Figure 1).

Prevalence of overweight and obesity by seafarer's rank

A significant difference between BMI categories and rank group [X^2 (2) = 7.54, $p = .023$] was noticeable. Almost 40% and 9% of the total subjects were overweight and obese, respectively. The high number of non-officers was overweight (42%) and obese (10.5%) compared to officers (Figure 2).

Distribution of blood pressure by different BMI categories

As shown in Figure 3, 46% and 24.7% of overweight seafarers had prehypertension and hypertension, respectively. The maximum percentage of obese study subjects had prehypertension (47%) and hypertension (39%). The differences in blood pressure levels across various BMI categories were statistically significant ($X^2(2) = 92.71$, $p < .001$).

Mean systolic and diastolic blood pressure in different age and BMI category

Both the average systolic and diastolic blood pressure were lower for the age group less than or equal to 30 y. The highest mean systolic BP was found among the oldest age group (> =51 y), and the differences were also statistically significant. Average diastolic BP increased from the age group <=30 y to 31–40 y and from 41–50 y to >=51 y. The highest mean DBP was found in the age group 31–40 y and significantly differed across the age groups. The mean SBP and DBP increased from normal body weight to obese category. The minimum average value of systolic and diastolic blood pressure was found among normal bodyweight category, and maximum mean systolic and diastolic blood pressure were found in obese category. The differences both in average systolic and diastolic blood pressure between BMI categories were statistically significant (Table 2).

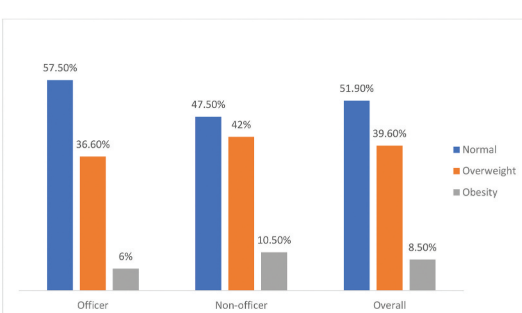

Figure 2. Percentage distribution of body mass index (BMI) levels by seafarer's rank group.

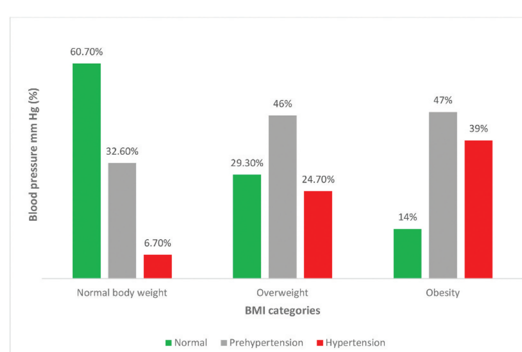

Figure 3. Percentage distribution of blood pressure among seafarers by BMI categories.

Table 2. Blood pressure among seafarers in different age groups and BMI categories.

	Number of participants **n(%)**	Systolic blood pressure (mmHg)				Diastolic blood pressure (mmHg)			
		Mean score	±SD	±SE	F-test	Mean score	±SD	±SE	F-test
Age group					4.332**				4.350***
≤30 y	161 (26.7)	124.33	7.97	0.63		82.09	4.95	0.39	
31–40 y	227 (37.6)	126.23	9.61	0.64		84.49	9.02	0.59	
41–50 y	124 (20.6)	125.16	12.49	1.12		82.60	7.66	0.69	
≥ 51 y	91 (15.1)	128.90	10.62	1.11		84.42	6.24	0.65	
BMI category					58.691***				65.773***
Normal	313 (51.9)	122.25	7.25	0.41		80.53	4.47	0.25	
Overweight	239 (39.6)	128.84	9.81	0.63		85.98	8.14	0.53	
Obesity	51 (8.5)	134.61	15.68	2.19		89.51	10.64	1.49	

Significant at the **p < 0.01, ***p < 0.001, F-test: variance-ratio test.

Table 3. Correlation matrix between blood pressure, BMI and age in seafarers.

Variables	BMI	Systolic BP	Diastolic BP	Age
BMI	1.00	0.336**	0.344**	0.313**
Systolic blood pressure	0.336**	1.00	0.640**	0.174**
Diastolic blood pressure	0.344**	0.640**	1.00	0.122**
Age	0.313**	0.174**	0.122**	1.00

Statistically significant at the **p < 0.01(2-tailed).

Body mass index and blood pressure

A positive and statistically significant correlation of BMI with both systolic BP and diastolic BP was observed. This study showed that blood pressure increases while increasing BMI. The correlation of BMI with diastolic BP was stronger when compared to systolic BP. Age was also positively and significantly correlated with systolic and diastolic blood pressure. However, the correlation of age with BMI was stronger than with systolic and diastolic BP (Table 3) .

Body mass index as a risk factor for high blood pressure

The multinomial regression analysis revealed that BMI and rank of seafarers were the significant predictors of high blood pressure. The odds of prehypertension and hypertension were more than eight and sixteen folds among obese individuals. Non-officers had a significantly higher risk of both prehypertension and hypertension compared to the officers. Being physically active and nonsmoker had a lower risk for both prehypertension and hypertension, but not statistically significant. As assessed by blood pressure, those who were overweight were 3.62 and 6.70 times more likely to have prehypertension and hypertension, respectively, than those who were in the normal BMI groups (Table 4).

Discussion

This study has examined the relationship between BMI and BP, both SBP and DBP among seafarers. As a result, BMI was positively and significantly correlated with both systolic and diastolic blood pressure. However, the relationship between BMI and diastolic blood pressure (r = 0.344) was observed to be stronger than systolic blood pressure (r = 0.336). Besides, a significant positive correlation was observed between age and both SBP and DBP in seafarers, although the correlation coefficients were weak [r = 0.174 (SBP) and r = 0.122 (DBP)]. On the other hand, the correlation of age with BMI was found to be stronger than with both systolic and diastolic blood pressure. There is no earlier comparable research regarding the relationship between BMI and BP in seafarers.

This study showed that the average BMI, SBP, and DBP were significantly higher among non-officers compared to the officers by rank group ($p < .001$). Mean SBP and DBP increased significantly with age consistently from the younger age groups (≤30 y) to the older age groups (greater than or equal to 51 y) of individuals. This shows that the dependence of blood pressure on the age of seafarers. Similarly, the average systolic and

Table 4. Determinants of high blood pressure among seafarers estimated with a multinomial logistic regression model (n = 603).

	Blood Pressure (mmHg)			
	Prehypertension		Hypertension	
	OR (95% CI)	P- value	OR (95% CI)	P-value
BMI category				
Normal	1		1	
Overweight	3.62 (2.35–5.58)***	<0.001	6.70 (3.74–12.01)***	<0.001
Obesity	8.24 (3.59–18.88)***	<0.001	16.75 (6.57–42.73)***	<0.001
Rank group				
Officer	1		1	
Non-officer	3.39 (2.21–5.20)***	<0.001	4.83 (2.75–8.46)***	<0.001
Cigarette smoking				
No	0.98 (0.63–1.52)	0.925	0.80 (0.47–1.37)	0.153
Yes	1		1	
Physical activity				
No	1		1	
Yes	0.87 (0.48–1.59)	0.657	0.78 (0.35–1.74)	0.540

Significant at the ***P<0.001, the odds ratio was adjusted for age.

diastolic BP increased significantly with increasing BMI steadily from healthy body weight to obese category. Thus, mean systolic and diastolic blood pressure increased with increasing BMI levels.

Our study documented that nearly 40% and 9% of the study participants were overweight and obese, respectively. Similar findings were documented in other studies carried out in seafarers (36,38). Our finding was not consistent with the study conducted among Danish sailors, which reported 70.8% overweight (41). Another study reported 76.6% and 30.9% of overweight and obesity, respectively, among Danish seafarers (42). The rank-specific prevalence of overweight and obesity significantly increased among non-officers compared to officers. This might be due to work-related stress and poor psychological emotions (e.g., depression, anxiety, and negative emotions) because non-officers (deck crew and engine crew) work is characterized by night shift work, long working hours, short average sleep time and often sleep interruptions, and physical stress. Several studies have reported that work-related stress and negative emotions (e.g., negative mood) are risk factors for high BMI (overweight and obesity) by promoting poor health behaviors, such as unhealthy diet, insufficient physical activity, excessive alcohol use, and smoking (43–46). Thus, work-related stress contributes to bodyweight gain (43) and abdominal obesity (47,48). We found that a high number of overweight individuals had prehypertension (46%). Furthermore, the maximum percentage of obese subjects in the study had prehypertension (47%) and hypertension (39%). In other words, the prevalence of both prehypertension and hypertension significantly higher in individuals who were overweight and obese than those of healthy bodyweight categories.

This study found a high prevalence of both prehypertension and hypertension among non-officers when compared to officers. Also, the difference between high blood pressure distribution between rank groups was statistically significant ($p < .001$). In other words, the prevalence of high blood pressure was significantly higher in non-officers (65.7%), with 43% being prehypertensive and 22.4% being hypertensive. This could be due to work stress and hectic activity onboard ships. Officers have high-level responsibilities such as navigation, planning, and control of the ship (12,49). In contrast, non-officers' jobs are characterized by mooring and unmooring the vessel, loading, and unloading cargo (49,50); hence, non-officers works are physically more demanding and stressful than officer's jobs. Different studies have revealed that job-related stress contributes to the development of coronary heart diseases (CHD) (19) and metabolic syndromes (51), such as high blood pressure.

In this study, multinomial logistic regression analysis identified overweight, obesity, and rank of the seafarers as significant determinants of both prehypertension and hypertension. The odds of high blood pressure, both prehypertension, and hypertension more than three and four folds among non-officers compared to officers. The risk of elevated blood pressure is significantly higher among individuals with overweight and obesity categories. In other words, the odds of prehypertension and hypertension were 3.62 and 6.70 times higher among individuals who were overweight compared to the normal bodyweight categories. Similarly, the odds of prehypertension among those in obesity categories were 8.24 times higher than individuals in healthy bodyweight categories. The risk of hypertension was significantly highest among individuals in the obesity groups [OR = 16.70, 95% CI: 6.57–42.73; $p < .001$] compared to those who were in the healthy bodyweight categories. Being physically active and not smoking had a lower risk of hypertension, although the difference was not statistically significant. Our work was limited by the use of retrospective data, and we did not have some important variables such as dietary variables, which could be potential confounders or mediators for the observed associations. Additionally, we did not consider information on antihypertensive medication due to a lack of information in the datasets. However, our work is the first to examine the relationship between BMI and blood pressure in seafarers.

Conclusion

The present study showed a positive and significant relationship between BMI and blood pressure. There were significant positive correlations between BMI, age, SBP, and DBP, although the magnitude of the correlation differed. Our work documented a significantly high prevalence of prehypertension among overweight and obese seafarers. Furthermore, overweight and obesity are strong predictors for high blood pressure, both prehypertension and hypertension in seafarers. The risk of high blood pressure was highest among individuals who were obese. In other words, blood pressure increases while increasing BMI levels. Hence, attention should be given on weight management program in relation to the prevention and control of high blood pressure. Seafarer health interventions targeting to reduce BMI would have significant effects in reducing the burden of high blood pressure on board ships.

Acknowledgments

The authors would like to express their sincere gratitude to all C.I.R.M. staff for their invaluable support for this study.

Funding

This work was supported by the International Transport Workers' Federation (ITF) Trust, London, UK, under grant number 558 to C.I.R.M. Institutional funding of the University of Camerino, Italy, supported Ph.D. bursaries to GGS.

Ethical considerations

The study has been reviewed and approved by the C.I.R.M. ethics, scientific, and medical committee. Seafarers gave written informed consent to C.I.R.M. during a medical examination for the examinations as well as for the use of their medical data in anonymous form for research purposes related to the investigation of their health condition and for epidemiological studies.

Disclosure of interest

The authors report no conflict of interest.

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Authors' contributions

GGS designed study, performed analysis, methodology, interpreted the data and results, and drafted manuscript. MD extracted data and participated in manuscript preparation. FA guided, edited, reviewed, and approved the study. All authors approved the final manuscript.

References

1. World Health Organization. Hypertension. 2019. [Accessed 2020 Aug 16]. https://www.who.int/health-topics/hypertension/#tab=tab_1
2. Lawes CMM, Vander HS, Rodgers A, Society I. 2001. Global burden of blood-pressure-related disease, 2001. Lancet. 371 (9623):1513–18. doi:10.1016/S0140-6736(08)60655-8
3. World Health Organization. Obesity and overweight. 2020. [Accessed Aug 16 2020]. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
4. Afshin A, Forouzanfar MH, Reitsma MB, Sur P, Estep K, Lee A, Marczak L, Mokdad AH, Moradi-Lakeh M, Naghavi M, et al. Health effects of overweight and obesity in 195 countries over 25 years. N Engl J Med. 2017;377(1):13–27. doi:10.1056/NEJMoa1614362.
5. Oldenburg M, Baur X, Schlaich C. 2010. Occupational risks and challenges of seafaring. J Occup Health. 52(5):249–56. doi:10.1539/joh.K10004
6. Sagaro GG, Amenta F. 2020. Past, present, and future perspectives of telemedical assistance at sea: a systematic review. Int Marit Health. 71(2):97–104. doi:10.5603/IMH.2020.0018
7. Mulić R, Vidan P. Comparative analysis of medical assistance to seafarers in the world and the republic of Croatia. *15th Int Conf Transp Sci.* 2012:1–8. Zrinsko Frankopanska 38, 21000 Split, Croatia. https://bib.irb.hr/datoteka/587264.Mulic_Vidan_Bosnjak.pdf
8. Oldenburg M, Herzog J, Harth V. Seafarer deaths at sea: A German mortality study. Occup Med (Chic Ill). 2016;66:135–37. doi:10.1093/occmed/kqv153.
9. Alves PM, Leigh R, Bartos G, Mody R, Gholson L, Nerwich N. Cardiovascular events on board commercial maritime vessels: a two-year review. Int Marit Health. 2010;62(3):137–42. http://www.ncbi.nlm.nih.gov/pubmed/21154300.
10. Grappasonni I, Petrelli F, Amenta F. Deaths on board ships assisted by the centro internazionale radio medico in the last 25 years. Travel Med Infect Dis. 2012;10:186–91.:doi:10.1016/j.tmaid.2012.06.006.
11. Berg HP, Factors H. 2013. 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. 7(3):107–15. doi:10.12716/1001.07.03.04
12. Oldenburg M, Jensen HJ. Stress and strain among seafarers related to the occupational groups. Int J Environ Res Public Health. 2019;16:7. doi:10.3390/ijerph16071153.
13. Harrington JM.Health effects of shift work and extended hours of work. Occup Environ Med. 2001;58(1):68–72.
14. Spurgeon A, Harrington JM, Cooper CL. 1997. Health and safety problems associated with long working hours: A review of the current position. Occup Environ Med. 54(6):367–75. doi:10.1136/oem.54.6.367
15. Hjarnoe L, international AL-H promotion, 2014. A risky occupation?(Un) healthy lifestyle behaviors among Danish seafarers. *academic.oup.com*. [Accessed 2020 June 11]. https://academic.oup.com/heapro/article-abstract/29/4/720/565098
16. Oldenburg M, Jensen HJ, Latza U, Baur X. 2008. Coronary risks among seafarers aboard German-flagged ships. Int Arch Occup Environ Health. 81(6):735–41. doi:10.1007/s00420-007-0261-5
17. Almadi T, Cathers I, Chow CM. 2013. Associations among work-related stress, cortisol, inflammation, and metabolic syndrome. Psychophysiology. 50(9):821–30. doi:10.1111/psyp.12069
18. Kaltsas G, Vgontzas A, Chrousos G. 2010. Fatigue, Endocrinopathies, and Metabolic Disorders. Pm R. 2(5):393–98. doi:10.1016/j.pmrj.2010.04.011
19. Cooper CARYL, Marshall JUDI.Occupational sources of stress: a review of the literature relating to coronary heart disease and mental ill health. J Occup Psychol. 1976;49(1):11–28.
20. Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. 2006. Work stress in the etiology of coronary heart disease - A meta-analysis. Scand J Work Environ Heal. 32 (6):431–42. doi:10.5271/sjweh.1049
21. Polonikov AV, Vialykh EK, Churnosov MI, Illig T, Freidin MB, Vasil'eva OV, Bushueva OY, Ryzhaeva VN, Bulgakova IV, Solodilova MA. The C718T polymorphism in the 3′-untranslated region of glutathione peroxidase-4 gene is a predictor of cerebral stroke in patients with essential hypertension. Hypertens Res. 2012;35(5):507–12. doi:10.1038/hr.2011.213.
22. Kannel WB. 2004. Hypertensive risk assessment: Cardiovascular risk factors and hypertension. J Clin Hypertens (Greenwich). 6(7): 393-9. doi: 10.1111/j.1524-6175.2004.03605.x.
23. Labarthe D, Ayala C. 2002. Nondrug interventions in hypertension prevention and control. Cardiol Clin. 20(2):249–63. doi:10.1016/S0733-8651(01)00003-0
24. Kirkutis A, Norkiene S, Griciene P, Gricius J, Yang S, Gintautas J. Prevalence of hypertension in Lithuanian mariners. Proc West Pharmacol Soc. 2004;47:71–75.
25. Tu M, Jepsen JR. 2016. Hypertension among Danish seafarers. Int Marit Health. 67(4):196–204. doi:10.5603/IMH.2016.0037
26. Møller Pedersen SF, Jepsen JR. 2013. The metabolic syndrome among Danish seafarers. Int Marit Health. 64(4):183–90. doi:10.5603/IMH.2013.0002
27. Dua S, Bhuker M, Sharma P, Dhall M, Kapoor S. 2014. Body mass index relates to blood pressure among adults. N Am J Med Sci. 6 (2):89–95. doi:10.4103/1947-2714.127751
28. Vuvor F. 2017. Correlation of Body Mass Index and Blood Pressure of Adults of 30–50 Years of Age in Ghana. J Heal Res Rev. 4 (3):26–32. doi:10.4103/jhrr.jhrr
29. Tesfaye F, Nawi NG, Van Minh H, Byass P, Berhane Y, Bonita R, Wall S. Association between body mass index and blood pressure across three populations in Africa and Asia. J Hum Hypertens. 2007;21(1):28–37. doi:10.1038/sj.jhh.1002104.
30. Linderman GC, Lu J, Lu Y, Sun X, Xu W, Nasir K, Schulz W, Jiang L, Krumholz HM. Association of body mass index with blood pressure among 1.7 million Chinese adults. JAMA Netw open. 2018;1(4):e181271. doi:10.1001/jamanetworkopen.2018.1271.
31. Chen H, Zhang R, Zheng Q, Yan X, Wu S, Chen Y. 2018. Impact of body mass index on long-term blood pressure variability: A cross-sectional study in a cohort of Chinese adults. BMC Public Health. 18(1):1–8. doi:10.1186/s12889-018-6083-4
32. Mungreiphy NK, Kapoor S, Sinha R. Association between BMI, Blood Pressure, and Age: study among Tangkhul Naga Tribal Males of Northeast India. J Anthropol. 2011;2011:1–6. doi:10.1155/2011/748147.
33. Ravisankar P, Madanmohan UK, Prakash ES.Correlation between body mass index and blood pressure indices, handgrip strength and handgrip endurance in underweight, normal weight and overweight adolescents. Indian J Physiol Pharmacol. 2005;49 (4):455–61.
34. Rafiee E, Khaledi M, Madmoli M, Zafari M, Lotfizadeh M.The Correlation between Blood Pressure and BMI in Students of

Shahrekord University of Medical Sciences in 2013-14. Int J Ayurvedic Med. 2013;10(1):113–17.

35. Kaushik D, Chawla GK. Correlation between blood pressure and body mass index among University students. Int J Heal Sci Res. 2019;9(August):394–98.
36. Baygi F, Jensen OC, Qorbani M, Farshad A, Salehi SA, Mohammadi-Nasrabadi F, Asayesh H, Shidfar F. Prevalence and associated factors of cardio-metabolic risk factors in Iranian seafarers. Int Marit Health. 2016;67(2):59–65. doi:10.5603/IMH.2016.0013.
37. Hjarnoe L, Leppin A. 2014. A risky occupation? (Un)healthy lifestyle behaviors among Danish seafarers. Health Promot Int. 29 (4):720–29. doi:10.1093/heapro/dat024
38. Nittari G, Tomassoni D, Di Canio M, Traini E, Pirillo I, Minciacchi A, Amenta F. Overweight among seafarers working on board merchant ships. BMC Public Health. 2019;19:1.
39. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, et al. Seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. Hypertension. 2003;42(6):1206–52. doi:10.1161/01.HYP.0000107251.49515.c2.
40. World Health Organization. *Obesity: preventing and managing the global epidemic report of a WHO consultation (WHO technical report series 894)*. 1999. [Accessed Aug 16, 2020]. https://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/
41. Hansen HL, Hjarnoe L, Jepsen JR.Obesity continues to be a major health risk for Danish seafarers and fishermen. Int Marit Heal. 2011;62(2):98–103.
42. Hoeyer JANL, Hansen HL. OBESITY AMONG DANISH SEAFARERS. Int Marit Heal. 2005;56:1–4.
43. Faghri PD, Mignano C, Huedo-Medina TBCM. 2015. Psychological health and overweight and obesity among high stressed work environments. Obes Open Access. 1(1):1–23. doi::10.16966/2380-5528.101
44. Wardle J, Steptoe A, Oliver G, Lipsey Z. Stress, dietary restraint and food intake. J Psychosom Res. 2000;48:195–202.
45. Kirk MA, Rhodes RE. 2011. Occupation correlates of adults' participation in leisure-time physical activity. Am J Prev Med. 40 (4):476–85. doi:10.1016/j.amepre.2010.12.015
46. Twisk JOSWR, Snel JAN, Kemper HANCG, Van MW. Changes in daily hassles and life events and the relationship with coronary heart disease risk factors : a 2-year longitudinal study in 27–29-year-old males and females. J Psychosom Res. 1999;46(3):229–40.
47. Wardle J, Chida Y, Gibson EL, Whitaker KL, Stress SA. 2009. Adiposity : A Meta-Analysis of Longitudinal Studies. Obesity. 19 (4):771–78. doi:10.1038/oby.2010.241
48. Caban AJ, Lee DJ, Fleming LE, Gómez-marín O, Leblanc W, Pitman T. 2005. Obesity in US workers : the national health interview survey, 1986 to 2002. Am J Public Health. 95(9):1614–22. doi:10.2105/AJPH.2004.050112
49. STCW. International convention on standards of training, certification and watchkeeping for seafarers. IMO. 1995. [Accessed 2020 May 2]. http://www.imo.org/en/OurWork/humanelement/trainingcertification/pages/stcw-convention.aspx
50. Oldenburg M, Jensen HJ, Latza U, Baur X. 2009. Seafaring stressors aboard merchant and passenger ships. Int J Public Health. 54 (2):96–105. doi:10.1007/s00038-009-7067-z
51. Chandola T, Brunner E, Marmot M. Chronic stress at work and the metabolic syndrome: prospective study. BMJ. 2006;80:1–5. doi:10.1136/bmj.38693.435301.80.

VIA MEDICA

ORIGINAL ARTICLE

Int Marit Health
2021; 72, 4: 252–258
10.5603/IMH.2021.0049
www.intmarhealth.pl

ISSN 1641-9251
eISSN 2081-3252

A descriptive epidemiological study of cardiovascular diseases among seafarers

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ABSTRACT

Background: *Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality among seafarers. This study aimed to evaluate CVDs distribution and differences, considering seafarers' rank and worksite groups.*

Materials and methods: *A descriptive epidemiological study was employed, and the analysis was based on the telemedical assistance data of the International Radio Medical Centre (C.I.R.M.) from 2010 to 2018. The age, gender, rank, and worksite variables were considered for the analysis. Chi-square or Fisher test was used to assess differences in CVD distribution between rank and worksite groups.*

Results: *Cardiovascular diseases were the sixth leading cause of medical advice requests to C.I.R.M. Distribution of CVD significantly differed between officers and non-officers [x^2 (5) = 17.308, p = 0.004]. Officers were often diagnosed with hypertensive CVD (46%), whereas non-officers were frequently diagnosed with ischaemic heart diseases (41%). There were no significant differences in the distribution of CVD diagnoses between worksite groups [x^2 (10) = 12.863, p = 0.231].*

Conclusions: *The frequency of CVD is higher among non-officers and older seafarers who have been more often diagnosed with CVD. Specific interventions such as early diagnosis, regular monitoring, and physical training to reduce cardiovascular risk should be considered on board ships. Future studies should take into account the incidence rate of CVD between rank and worksite groups.*

(Int Marit Health 2021; 72, 4: 252–258)

Key words: cardiovascular diseases, epidemiology, seafarers, hypertensive disease, ischaemic heart disease

INTRODUCTION

Cardiovascular diseases (CVD) are the term defining several pathologies affecting the cardiovascular system. These include coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic and congenital heart diseases, and venous thromboembolism [1]. CVD is the leading cause of death worldwide, with approximately 17.9 million people dying per year and representing 31% of all global deaths. Of these deaths, about 7.4 million and 6.7 million were due to coronary heart disease and stroke, respectively [2]. In 2015, more than 1.6 million seafarers were employed worldwide, of which approximately 775,000 and 875,000 were officers and ratings, respectively [3]. In general, nautical work is broadly grouped by working place on board ships, including deck, engine, and galley [4], based on the differences between professional duties on board. CVD is the number one cause of death among seafarers, and the mortality rates on board are higher than those observed on shore [5–7]. Workers at sea have high mortality, injuries, and illnesses, probably as a consequence that they are working in hazardous environments.

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Different studies revealed that modifiable lifestyles such as tobacco use, harmful use of alcohol, physical inactivity, and unhealthy diet together with other significant risk factors, including increased arterial pressure, blood glucose levels, elevated blood lipids, overweight, and obesity, are the most critical. The above risk factors are causally linked with CVD, which represent the leading causes of deaths and disability in most countries [8–13]. Overweight and obesity represent relevant CVD risk factors for seafarers, and in these workers occur more often than in the general population [14]. A study conducted on the board of Italian flagship (2019) reported that more than 40% and 10% of seafarers were overweight and obese, respectively [15]. Another work on Iranian seafarers revealed that overweight increased from 46.7% to 60.9% over the period of 3 years [16]. These results indicate that in seafarers' CVD risk factors become worse compared to ashore workers. Other risk factors like gender, stress, depression and age are causes of CVD, and the reduction of these risk factors decreases the burden of CVD in all age groups [17]. Mental, psychological, and physical stressors represent other factors influenced by work-related issues [18]. These include isolation from family, long working hours, lack of shore leave, fatigue, exposure to different unhealthy lifestyles, and others [18–23] and make seafarers at a higher risk of CVD than the general population.

Ischaemic heart disease (IHD) and stroke are the principal components of the CVD burden globally and contributed to approximately 15.2 million deaths in 2015 [24, 25]. This accounts for more than 85% of all deaths due to CVD in the same year [24]. IHD and stroke cases increased, from 7.3 to 8.93 million and from 5.29 to 6.17 million deaths, respectively, between 2007 and 2017 [26]. The incidence and mortality rate of IHD has decreased in high-income countries in the last 25 years [25, 27, 28]. In contrast, the prevalence and mortality rate for this pathology is increased remarkably with age in developing countries and Eastern Europe [25, 27]. This suggests that CVD is reversing in developed countries and needs more attention in developing countries [26].

To meet the global health policy goal of reducing CVDs, further analysis of epidemiological data focusing on location, age, and time patterns is important [26]. This is because countering risk factors represents a health target in sustainable development goals for CVD reduction [25, 29]. In addition, the global efforts to reduce the CVD burden should be evidence-based [25] and centred on analysing the prevalence trends of these disorders.

Cardiovascular disease needs attention in commercial maritime operations because a high proportion of CVD death rate was recorded at sea among sailing seafarers [30–33]. Moreover, seafarers are exposed to different work-related stressors and potential complications like the risk of sudden cardiac arrest. In view of this, studies should provide evidence-based information about the CVD burden in the case of seafarers to handle events effectively [6].

The present work has evaluated the CVD distribution and differences between the rank and the seafarers' worksite. The analysis was made based on medical assistance data to seafarers provided by Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.), the Italian Telemedical Maritime Assistance Service (TMAS).

MATERIALS AND METHODS

A descriptive epidemiological study was used to evaluate the distribution and differences in CVD occurrence between occupational groups and seafarers' worksites from 2010 to 2018.

DATA SOURCE AND COLLECTION PROCEDURES

Data were obtained from the C.I.R.M. database. C.I.R.M. is a non-profit institution established in 1935 which provides worldwide telemedical assistance to sailing seafarers [34]. The Centre was appointed in 2002 as the Italian TMAS and is the type of organization with the largest experience worldwide in terms of the number of patients assisted on board ships. For the last 84 years (from April 1935 to December 2019), the C.I.R.M. assisted more than 101,600 patients' on board ships and received 686,163 calls for medical consultations, with an average of 6 calls per patient. Data of C.I.R.M. assistance are available for each year with their gender, age, country, duties, and the diagnosis was encoded by both World Health Organization (WHO) International Classification of Diseases (ICD) 9th and ICD 10th versions. We used for this study data from 2010 to 2018 because, until 2009, data were encoded by ICD 9th version, but we considered 2010 and onwards data in which diagnoses were classified according to the ICD 10th version. In this version, the cardiovascular disease ICD code is from I00–I99. Diseases affecting seafarers were therefore classified into IHD (I20–I25), hypertensive disease (I10–I15), acute rheumatic fever (I00–I02), chronic rheumatic heart disease (I05–I09), pulmonary heart disease, and diseases of pulmonary circulation (I26–I28). Other forms of heart disease (I30–I52), cerebrovascular disease (I60–I69), diseases of arteries, arterioles, and capillaries (I70–I79), diseases of veins, lymphatic vessels, and lymph nodes, not elsewhere classified (I80–I89) and unspecified disorders of the circulatory system (I95–I99) [35] were also considered.

All recorded medical data are stored in the C.I.R.M. database, which is not accessible for externals. Data extraction, compiling, and coding were then performed. The attributes collected from each diagnosis were age, gender, occupational rank, and worksite. Age was calculated by subtracting the seafarer's date of birth from the date of medical advice provision. Seafarers, the date of birth of which was not available, were excluded from this study.

STATISTICAL ANALYSIS

Descriptive analysis of seafarers' demographic variables, including age, gender, rank, and worksite, was done to evaluate the distribution of CVDs. Quantitative attributes like age and sex were encoded and categorized. For example, the age of seafarers was categorized into five groups: less than or equal to 30 years (age group 1), 31–40 years (age group 2), 41–50 years (age group 3), 51–60 years (age group 4) and older than 60 years (age group 5). Occupational rank was stratified by officers (deck and engine officers) and non-officers (deck and engine ratings, and galley), whereas worksites were categorized into three groups, namely deck, engine, and galley. Chi-square or Fisher's exact test was used to analyse distributional differences in rank and worksite groups. Data analysis was made using the IBM SPSS Statistics software version 26.

RESULTS

DEMOGRAPHIC CHARACTERISTICS

Overall, 1,377 CVD cases were assisted by C.I.R.M. during the 9 years under study. Almost all (98%) seafarers examined with CVD were male, and the average age (± standard deviation) of the patients with CVDs was 48.35 ± 12.71 years. CVD was frequently diagnosed in seafarers aged 51–60 years (31% of all seafarers with CVD). CVD occurred more often in non-officers compared to officers (748 [54.3%] vs. 629 [45.7%]) and was almost 2 and 9 times more frequent in the deck than in the engine and galley workers (Table 1).

Table 1. Demographic characteristics of seafarers with cardiovascular disease from 2010 to 2018

Variable	Number of cases (n = 1,377)	Frequency (%)
Age group		
≤ 30	133	9.7
31–40	231	16.8
41–50	385	28
51–60	429	31
> 60	199	14.5
Mean (SD)	48.35 ± 12.71	
Gender		
Male	1,345	98
Female	32	2
Rank		
Officer	629	45.7
Non-officer	748	54.3
Worksite		
Deck	807	59
Engine	479	35
Galley	91	6

SD — standard deviation

Cardiovascular disease was the sixth leading cause for accessing the C.I.R.M. Other cases such as gastrointestinal disease and injury/trauma were the first and second most frequent causes of pathologies assisted among seafarers and accounted for 5,372 (16.60%) and 5,330 (16.40%) of all medical events, respectively, during the study period (Fig. 1).

The frequencies of different CVD diagnoses are shown in Figure 2. The most frequent CVD were hypertensive diseases (n = 551; 40%) and IHD (n = 530; 38.5%). Among hypertensive diseases, arterial hypertension was the most frequently diagnosed (89% of the total hypertensive diseases), whereas other types of hypertensive diseases such as hypertensive heart disease, renal diseases, and secondary hypertension accounted for 11% of the total hypertensive diseases. IHD included unspecified angina pectoris (376 cases), acute myocardial infarction (132 cases), and other forms of angina pectoris (22 cases).

The other heart disease forms were the third most often diagnosed CVD, accounting for approximately 7% (95) of pathologies of this group. A common diagnosis of other forms of heart disease included cardiac arrest (62 cases), paroxysmal tachycardia (26 cases), and other cardiac arrhythmias (7 cases). Cerebrovascular diseases were also diagnosed in 59 seafarers and accounted for over 4% of total CVD. The most often cerebrovascular diagnosis included stroke, which is responsible for 80% of total cerebrovascular cases. Cerebral infarction accounted for the remaining 20% of cerebrovascular diseases.

Diseases of veins and lymphatic vessels were responsible for nearly 4% (50) of medical advice requests received. 91% of these pathologies included phlebitis and thrombophlebitis. The remaining 9% consisted of portal vein thrombosis and varicose veins of other sites.

DIFFERENCES BETWEEN OFFICERS AND NON-OFFICERS IN CVD DISTRIBUTION

The average age of officers and non-officers with CVD was 48.21 ± 13.08 years and 48.47 ± 12.44 years, respectively. CVD was frequently diagnosed in officers aged 41 to 50 years and in non-officers aged 51 and 60 years during the study period (Fig. 3).

Officers were frequently diagnosed with hypertensive CVDs (46%), whereas non-officers were often diagnosed

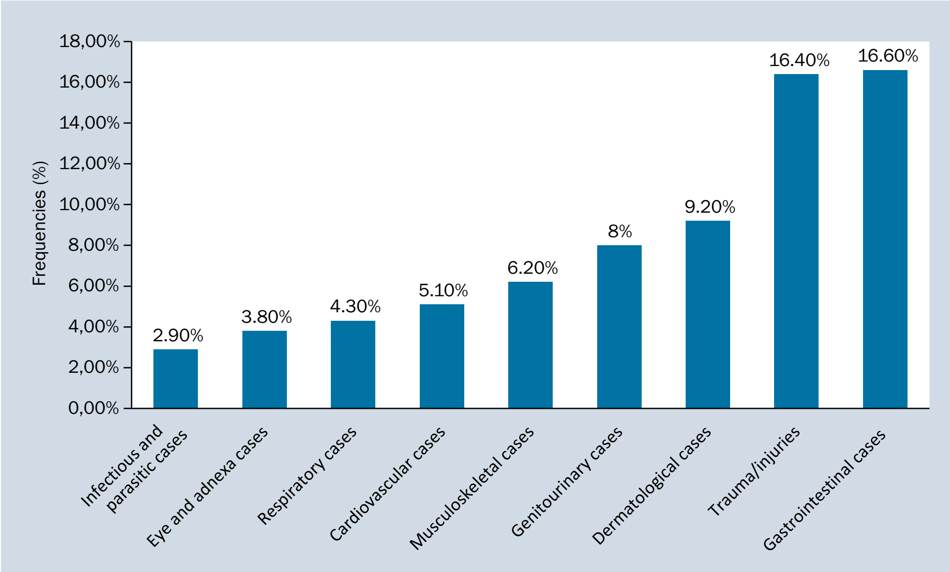

Figure 1. Frequencies (%) of pathologies assisted by Centro Internazionale Radio Medico (International Radio Medical Centre, C.I.R.M.) from 2010 to 2018

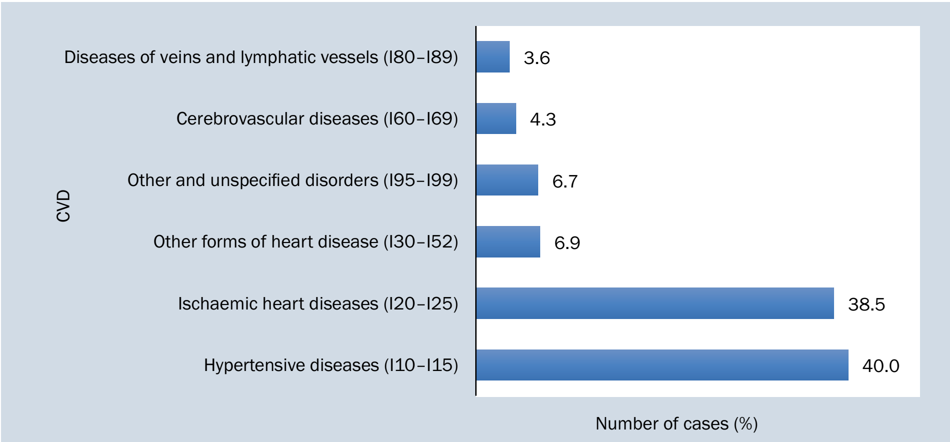

Figure 2. Frequencies (%) of cardiovascular diseases (CVD) diagnosis according to World Health Organization (WHO) International Classification of Diseases (ICD) 10th category from 2010 to 2018 (n = 1,377)

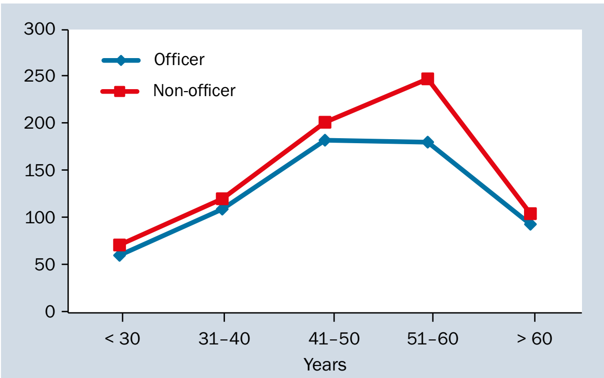

Figure 3. Distribution of cardiovascular diseases by age group between officers and non-officers with cardiovascular cases from 2010 to 2018

with IHDs (41%). The observed frequencies and percentages of each type of CVD diagnosis by seafarer rank are summarised in Table 2. The distribution of CVD diagnosis between officers and non-officers was significantly different [x^2 (5) = 17.308, p = 0.004] (Table 2).

DISTRIBUTIONS OF CVD BETWEEN WORKSITE GROUPS ONBOARD SHIPS

We found that deck workers were often diagnosed with IHD (41.9%), while engine room workers (43.8%) and galley (46.2%) were frequently diagnosed with hypertensive diseases. There was no difference in distribution of CVD diagnosis between worksite groups [x^2 (10) = 12.863, p = 0.231] (Table 3).

Table 2. Distribution of cardiovascular diseases by seafarer rank from 2010 to 2018 (n = 1,377)

Types of cardiovascular diseases	Rank		P-value
	Officer	Non-officer	
Total	629 (100)	748 (100)	0.004
Hypertensive diseases (I10–I15)	288 (46%)	263 (35%)	
Ischaemic heart diseases (I20–I25)	220 (35%)	310 (41%)	
Other forms of heart disease (I30–I52)	39 (6%)	56 (7%)	
Cerebrovascular diseases (I60–I69)	21 (3%)	38 (5%)	
Diseases of veins and lymphatic vessels (I80–I89)	23 (4%)	27 (4%)	
Other and unspecified disorders (I95–I99)	38 (6%)	54 (7%)	

Table 3. Distribution of cardiovascular diseases by seafarer worksites from 2010 to 2018 (n = 1,377)

Types of cardiovascular diseases	Worksites			P-value
	Deck	Engine	Galley	
Total	807 (100%)	479 (100%)	91 (100%)	0.231
Hypertensive diseases (I10–I15)	299 (37%)	210 (43.8%)	42 (46.2%)	
Ischaemic Heart diseases (I20–I25)	338 (41.9%)	162 (33.8%)	30 (32.9%)	
Other forms of heart disease (I30–I52)	54 (6.7%)	35 (7.3%)	6 (6.6%)	
Cerebrovascular diseases (I60–I69)	36 (4.5%)	20 (4.2%)	3 (3.3%)	
Diseases of veins and lymphatic vessels (I80–I89)	32 (3.9%)	15 (3.2%)	3 (3.3%)	
Other and unspecified disorders (I95–I99)	48 (5.9%)	37 (7.7%)	7 (7.7%)	

DISCUSSION

Over 9 years (from 2010 to 2018), there were 1,377 contacts to C.I.R.M due to CVD. Among the medical advice requests, 40% and 38.5% were respectively for hypertensive and IHD. The remaining 21.5% were for other heart disease forms, cerebrovascular diseases, diseases of veins and lymphatic vessels, and unspecified disorders of the circulatory system. In this study, we focused on the distribution and differences of CVD between the rank and the seafarers' worksite groups based on the assistance data of C.I.R.M. This type of analysis was chosen for practical reasons because it is difficult to estimate the incidence of CVD among seafarers without information on the total at-risk seafarer population on board ships.

In this study, we found that CVD was the sixth leading cause of accessing C.I.R.M. medical services. These results are not consistent with a German study [36] but in line with research conducted in the United States merchant vessels [6]. Nevertheless, these diseases are critical and one of the main health problems for seafarers. This is because factors such as exposure to the noise, job strain, and fatigue could increase CVD risk among seafarers. On the other hand, seafarers stay for long times away from their families, and they are experiencing many work-related issues such as physical, mental, and psychological stressors that can exacerbate the risk of developing CVD. Another study conducted on seafarers reported that vessel-specific stress, unhealthy diet, and lack of exercise were the major risk factor for CVD on board. This could be the reason for the not negligible occurrence of CVD among seafarers [38] in spite of the rather frequent cardiovascular pre-employment tests that people working at sea should make every 2 years. A study conducted in the modern maritime industry reported several work-related cardiac risk factors such as time pressure, long working hours, and high-stress factors are present on board [37].

The present study has shown that CVD distribution between officers and non-officers was significantly different [x^2 (5) = 17.308, p = 0.004], with non-officers having more CVD diagnoses than officers. This may be due to differences in stress management, lifestyle risk factors, and high work-related stressors. In addition, a recently conducted study among seafarers revealed that non-officers required a high level of physical effort to carry out their duties, and they had a higher risk of psychological stress than officers because of work-related risk factors [38]. This may explain our findings of different frequencies of CVD diagnoses between officers and non-officers. In contrast, no significant differences in CVD diagnosis by seafarer's worksite were noticeable.

In this study, hypertensive disease was the most common CVD, accounting for 40% of all cardiovascular cases. Arterial hypertension with 89% of diagnoses was the main CVD affecting seafarers. A Danish study revealed that arterial hypertension was the main health concern of seafarers. The same study reported 44.7% and 41.8% of the prevalence of hypertension and pre-hypertension, respectively, among Danish seafarers [39]. According to different studies, the prevalence of CVD was increased among seafarers because of unhealthy lifestyles such as smoking, a high-fat diet, and inadequate physical activity [36]. This may explain our findings of the elevated frequency of hypertensive disease diagnoses. Ischaemic heart disease was the second most frequent disorder in the present work, accounting for 39% of all cardiovascular diseases. The basic medical assistance level that can be offered to on board ships without doctors or adequately trained paramedics, complicated by the relevant limitations in terms of availability of diagnostic devices on board, makes our analysis rather generic. For instance, situations like unspecified angina pectoris would need additional tests to confirm the condition, but unfortunately, this is not possible in the large majority of merchant ships [6, 40]. Moreover, devices for precise CVD diagnoses such as electrocardiogram, echocardiogram, coronary angiogram, and myocardial imaging to minimise misdiagnosis and prevent treatment delay remain today a dream far becoming a reality. Despite the above limitations, our analysis, based on requests coming from the ship side at the time of occurrence of symptoms requiring medical care, represents a real-life survey of what happens in an isolated environment like a ship in the middle of the sea.

The present study showed that CVD frequently occurred in older seafarers on board, with 31% (429) of all CVD cases affecting people aged between 51 to 60 years. In other words, the distribution of CVD among older seafarers is threefold higher than in younger seafarers (less than or equal to 30 years). Our results are in line with those of a German study reporting that CVD distribution significantly varied between age groups among seafarers [36]. In other words, as expected, increasing age is associated with a higher likelihood of CVD. This observation should consider more deep fitting tests in older seafarers and an effective preventative measure targeting older age seafarers on board.

LIMITATIONS OF THE STUDY

This study has some limitations and strengths. It was a retrospective descriptive study, and in nature, it has its constraints, including variable incomplete. Other limitations are gender disproportion and not considering the nationality variable because these attributes for some seafarers were incomplete in the database. We have also not assessed the incidence rate or cumulative incidence because of the lack of control group data. However, this study has some strengths. This work has shown the case frequency and differences between occupational groups. This can give insights into cardiovascular problems' real occurrence and stimulate future incidence of CVD studies in merchant seafarers.

CONCLUSIONS

Non-officers had a higher frequency of CVD diagnosis compared to officers during the study period. Officers were frequently diagnosed with hypertensive CVDs, whereas non-officers often diagnosed with IHDs. Older seafarers aged 51 to 60 were the age group with a higher frequency of CVD. To prevent CVD distribution and reduce their burden on merchant seafarers, effective prevention measures such as early diagnosis, regular follow-up, and training crewmembers on basic life support and using automatic external defibrillators should be considered. In addition, telemonitoring equipment for cardiovascular diagnosis via telemedicine should be introduced on a large scale on board to guarantee higher quality medical assistance to sailing seafarers. Special attention should also be given to seafarers older than 50 years. Primary prevention focused on increased awareness of CVD risk factors, intensive health education campaigns, and regular medical check-ups on board should be considered with full attention.

FUNDING SOURCE AND ACKNOWLEDGEMENTS

The present study is part of an epidemiological analysis carried out in the frame of a project supported by the ITF Seafarers' Trust grant No. 1276/2018 to develop an intelligent system for improving medical assistance seafarers.

Conflict of interest: None declared

REFERENCES

1. World Health Organization, "Cardiovascular diseases (CVDs)," 2016. [Online]. https://www.who.int/en/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) (Accessed: 28-Mar-2019).
2. World Health Organization, "Cardiovascular Disease (CVD)," 2017. [Online]. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) (Accessed: 28-Mar-2019).
3. B.I.M.C.O. and I.C.S. Manpower Report-The global supply and demand for seafarers. Exec. Summ, 2015, p. 6.
4. Lefkowitz RY, Slade MD, Redlich CA. Injury, illness, and disability risk in American seafarers. Am J Ind Med. 2018; 61(2): 120–129, doi: 10.1002/ajim.22802, indexed in Pubmed: 29250811.
5. Oldenburg M, Herzog J, Harth V. Seafarer deaths at sea: a German mortality study. Occup Med (Lond). 2016; 66(2): 135–137, doi: 10.1093/occmed/kqv153, indexed in Pubmed: 26409049.
6. Alves PM, Leigh R, Bartos G, et al. Cardiovascular events on board commercial maritime vessels: a two-year review. Int Marit Health. 2010; 62(3): 137–142, indexed in Pubmed: 21154300.

7. Grappasonni I, Petrelli F, Amenta F. Deaths on board ships assisted by the Centro Internazionale Radio Medico in the last 25 years. Travel Med Infect Dis. 2012; 10(4): 186–191, doi: 10.1016/j.tmaid.2012.06.006, indexed in Pubmed: 22819258.
8. Buring JE, Hennekens CH. Prevention of cardiovascular disease: risks and benefits of aspirin. J Gen Intern Med. 1990; 5(5 Suppl): S54–-S57, doi: 10.1007/BF02600843, indexed in Pubmed: 2231066.
9. Yang ZJ, Liu J, Ge JP, et al. Prevalence of cardiovascular disease risk factor in the Chinese population: the 2007-2008 China National Diabetes and Metabolic Disorders Study. Eur Heart J. 2012; 33(2): 213–220, doi: 10.1093/eurheartj/ehr205, indexed in Pubmed: 21719451.
10. Rabani S, Sardarinia M, Akbarpour S, et al. 12-year trends in cardiovascular risk factors (2002-2005 through 2011-2014) in patients with cardiovascular diseases: Tehran lipid and glucose study. PLoS One. 2018; 13(5): e0195543, doi: 10.1371/journal.pone.0195543, indexed in Pubmed: 29768511.
11. Konings JWPM, Caliskan K, Balk AHHM, et al. Complexe revalidatie van een jongvolwassen patiënt: Niedaags, wel mogelijk Tijdschr. Tijdschr. voor Verpleeghuisgeneeskd. 2008; 33(4): 130–133, doi: 10.1161/CIR.0000000000000558.
12. Schweigman K, Eichner J, Welty TK. Cardiovascular disease risk factor awareness in American Indians to assess awareness of nine diseases among participants in the Strong Heart Study (S.H.S.). Ethnicity. 2006; 16: 2006.
13. Yusuf S, Reddy S, Ôunpuu S, et al. Global burden of cardiovascular diseases. Circulation. 2001; 104(22): 2746–2753, doi: 10.1161/hc4601.099487.
14. Szafran-Dobrowolska J, Renke M, Jeżewska M. Is it worth to continue to analyse the factors of cardiovascular risk among the sailors? Review of literature. Int Marit Health. 2019; 70(1): 17–21, doi: 10.5603/IMH.2019.0003, indexed in Pubmed: 30931513.
15. Nittari G, Tomassoni D, Di Canio M, et al. Overweight among seafarers working on board merchant ships. BMC Public Health. 2019; 19(1): 45, doi: 10.1186/s12889-018-6377-6, indexed in Pubmed: 30626365.
16. Baygi F, Jensen OC, Qorbani M, et al. Pattern of some risk factors of cardiovascular diseases and liver enzymes among Iranian seafarers. Med J Islam Repub Iran. 2017; 31: 23, doi: 10.18869/mjiri.31.23, indexed in Pubmed: 29445652.
17. Heart Foundation. Cardiovascular disease Factsheet. 2013, vol. 6, no. Cvd, pp. 138–141.
18. Carotenuto A, Molino I, Fasanaro AM, et al. Psychological stress in seafarers: a review. Int Marit Health. 2012; 63(4): 188–194, indexed in Pubmed: 24595974.
19. Allen P, Wadsworth E, Smith A. Seafarers' fatigue: a review of the recent literature. Int Marit Health. 2008; 59(1-4): 81–92, indexed in Pubmed: 19227741.
20. Iversen RTB. The mental health of seafarers. Int Marit Health. 2012; 63(2): 78–89, indexed in Pubmed: 22972547.
21. MacLachlan M, Kavanagh B, Kay A. Maritime health: a review with suggestions for research. Int Marit Health. 2012; 63(1): 1–6, indexed in Pubmed: 22669806.
22. Oldenburg M, Baur X, Schlaich C. Occupational risks and challenges of seafaring. J Occup Health. 2010; 52(5): 249–256, doi: 10.1539/joh.k10004, indexed in Pubmed: 20661002.
23. Slišković A, Penezić Z. Occupational stressors, risks and health in the seafaring population. Rev Psychol. 2016; 22(1-2): 29–39, doi: 10.21465/rp0022.0004.
24. Wang H, Naghavi M, Allen C, et al. Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016; 388(10053): 1459–1544, doi: 10.1016/s0140-6736(16)31012-1.
25. Joseph P, Leong D, McKee M, et al. Reducing the global burden of cardiovascular disease. Part 1: the epidemiology and risk factors. Circ Res. 2017; 121(6): 677–694, doi: 10.1161/CIRCRESAHA.117.308903, indexed in Pubmed: 28860318.
26. Roth G, Abate D, Abate K, et al. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980–2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018; 392(10159): 1736–1788, doi: 10.1016/s0140-6736(18)32203-7.
27. Moran AE, Forouzanfar MH, Roth GA, et al. The global burden of ischemic heart disease in 1990 and 2010: the Global Burden of Disease 2010 study. Circulation. 2014; 129(14): 1493–1501, doi: 10.1161/CIRCULATIONAHA.113.004046, indexed in Pubmed: 24573351.
28. Moran AE, Forouzanfar MH, Roth GA, et al. Temporal trends in ischemic heart disease mortality in 21 world regions, 1980 to 2010: the Global Burden of Disease 2010 study. Circulation. 2014; 129(14): 1483–1492, doi: 10.1161/CIRCULATIONAHA.113.004042, indexed in Pubmed: 24573352.
29. Go A, Mozaffarian D, Roger V, et al. Executive summary: heart disease and stroke statistics — 2014 update. Circulation. 2014; 129(3): 399–410, doi: 10.1161/01.cir.0000442015.53336.12.
30. Roberts SE. Mortality from disease among seafarers in British merchant shipping (1976-1995). Int Marit Health. 2002; 53(1-4): 43–58, indexed in Pubmed: 12608588.
31. Hansen HL. Surveillance of deaths on board Danish merchant ships, 1986-93: implications for prevention. Occup Environ Med. 1996; 53(4): 269–275, doi: 10.1136/oem.53.4.269, indexed in Pubmed: 8664966.
32. Puttfarken T. Causes and circumstances of deaths of Polish seafarers during seavoyages. J Travel Med. 1996; 3: 91–95, doi: 10.1111/j.1467-8365.1981.tb00741.x.
33. Larsson T, Lindquist C. Traumatic fatalities among Swedish seafarers 1984–1988. Safety Science. 1992; 15(3): 173–182, doi: 10.1016/0925-7535(92)90003-i.
34. Mahdi SS, Amenta F. Eighty years of CIRM. A journey of commitment and dedication in providing maritime medical assistance. Int Marit Health. 2016; 67(4): 187–195, doi: 10.5603/IMH.2016.0036, indexed in Pubmed: 28009394.
35. WHO. International Classification of Disease, Tenth Edition. 2011, pp. 1–195.
36. Oldenburg M. Risk of cardiovascular diseases in seafarers. Int Marit Health. 2014; 65(2): 53–57, doi: 10.5603/IMH.2014.0012, indexed in Pubmed: 25231325.
37. Oldenburg M, Baur X, Schlaich C. Cardiovascular diseases in modern maritime industry. Int Marit Health. 2010; 61(3): 101–106, indexed in Pubmed: 21154295.
38. Oldenburg M, Jensen HJ, Lucas D, et al. Stress and Strain among Seafarers Related to the Occupational Groups. Int J Environ Res Public Health. 2019; 16(7), doi: 10.3390/ijerph16071153, indexed in Pubmed: 30935082.
39. Tu M, Jepsen JR. Hypertension among Danish seafarers. Int Marit Health. 2016; 67(4): 196–204, doi: 10.5603/IMH.2016.0037, indexed in Pubmed: 28009392.
40. Review C. CLINICIAN' S CORNER Value and Limitations of Chest Pain History. Heal. (San Fr). 2006; 294(20): 57–58.

VIA MEDICA

LETTER TO THE EDITOR

Int Marit Health
2021; 72, 1: 76–77
10.5603/IMH.2021.0010
www.intmarhealth.pl

ISSN 1641-9251
eISSN 2081-3252

COVID-19 vaccine on board ships: current and future implications of seafarers

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The impact and effect of novel coronavirus disease 2019 (COVID-19) are expanding all over the world without boundaries. When it began in China in late 2019, it was seen to be not as scary and devastating as it has become today. However, the hope for overcoming the pandemic lies in finding an effective treatment and inventing a vaccine. If we look at the history of the spread of this contagion, within a short span of seven months it has spread all over the world. Statistics are saying that more than 104 million individuals got infected and 2.2 million deaths were currently occurred [1].

In the last few months, there has been a massive revelation in the medical domain regarding the outbreak of COVID-19 and its vaccination [2]. It has been truly amazing to see scientists and doctors come together across all over the world to share their expertise to develop vaccination in the past few months. Thanks to the collaboration between researchers and scientists are always way ahead to take up challenges and bear the torch of a bright and prosperous future as far as the COVID-19 struggle is concerned. To channelise their potential and encourage them to develop solutions by joining hand together in this pandemic time, the government has also been supportive of various initiatives and funding. Medical doctors sharing their experiences and the patients who have recovered from this near-fatal disease largely help in vaccine development. This brought a whole new perspective on how to handle the current situation the world is facing with the COVID-19 pandemic.

Seafarers are unsung heroes of this pandemic because shipping plays an important role in this serious outbreak. Unfortunately, because of the global emergency that happened in the last year, seafarers went through the depressive symptoms and faced various neuropsychological and psycho-affective alterations [3]. To slow down the rate of onboard infection, various shipping companies provided some serious guidelines such as social distancing at working places, self-hygiene, and room quarantine for any suspicious cases. For some seafarers, this situation is unbearable. Because of the novel pandemic, tens of thousands of sailors were stuck on board for more than a year now. Despite the fact of crew changes have been made conceivable in certain nations, the implementation stays exceptionally challenging. These situations demand immediate access to the vaccine for seafarers.

The speakers in the CrewConnect Global Virtual Event 2020 highlighted that, with some vaccine trials now showing promising results, sailors need to be treated as fundamental workers and be among the first to get vaccine [4]. "I think all the work we've done in lobbying governments now needs to be even more concerted effort about the point that seafarers are essential workers… we need to find a way to find a way to access vaccines" said Mr Stephen Cotton, general secretary of International Transport Workers Federation [4].

Some countries, such as Singapore, already started vaccination for seafarers and it becomes one of the first nations to give importance for COVID-19 vaccine to frontline workers of maritime. According to the Maritime and Port Authority of Singapore, seafarers need to undergo fewer testing before getting vaccinated. It is scheduled that at least 10,000 seafarers can be vaccinated by the end of January 2021 under air vaccination exercise [5].

COVID-19 is considered a type of pneumonia which can be effectively treated by vaccination. All national bodies have to step forward and take Singapore as an example in the provision of vaccine for frontline workers such as seafarers. On other hand, the International Maritime Or-

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ganization also urges that maritime workers and seafarers have to obtain COVID-19 vaccination on a priority basis to allow them to work freely and sustain dynamic global supply chain.

ACKNOWLEDGEMENTS

This paper was supported in part by the ITF Trust grant No. 1508/2020 to Centro Internazionale Radio Medico (C.I.R.M.).

REFERENCES

1. Home — Johns Hopkins Coronavirus Resource Center. https://coronavirus.jhu.edu/ (Feb 02, 2021).
2. Li Q, Lu H. Latest updates on COVID-19 vaccines. Biosci Trends. 2021; 14(6): 463–466, doi: 10.5582/bst.2020.03445, indexed in Pubmed: 33390384.
3. Battineni G, Sagaro GG, Chintalapudi N, et al. Assessment of awareness and knowledge on novel coronavirus (COVID-19) pandemic among seafarers. Healthcare (Basel). 2021; 9(2), doi: 10.3390/healthcare9020120, indexed in Pubmed: 33503921.
4. CrewConnect, Shipping needs to ensure seafarers prioritised for vaccines. https://www.seatrade-maritime.com/regulation/shipping-needs-ensure-seafarers-are-prioritised-covid-19-vaccines (Feb 02, 2021).
5. Singapore to prioritise maritime workers in Covid-19 vaccination effort | TradeWinds. https://www.tradewindsnews.com/people/singapore-to-prioritise-maritime-workers-in-covid-19-vaccination-effort/2-1-940231 (Feb 02, 2021).

infectious disease reports

Article

Sentimental Analysis of COVID-19 Tweets Using Deep Learning Models

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Abstract: The novel coronavirus disease (COVID-19) is an ongoing pandemic with large global attention. However, spreading false news on social media sites like Twitter is creating unnecessary anxiety towards this disease. The motto behind this study is to analyses tweets by Indian netizens during the COVID-19 lockdown. The data included tweets collected on the dates between 23 March 2020 and 15 July 2020 and the text has been labelled as fear, sad, anger, and joy. Data analysis was conducted by Bidirectional Encoder Representations from Transformers (BERT) model, which is a new deep-learning model for text analysis and performance and was compared with three other models such as logistic regression (LR), support vector machines (SVM), and long-short term memory (LSTM). Accuracy for every sentiment was separately calculated. The BERT model produced 89% accuracy and the other three models produced 75%, 74.75%, and 65%, respectively. Each sentiment classification has accuracy ranging from 75.88–87.33% with a median accuracy of 79.34%, which is a relatively considerable value in text mining algorithms. Our findings present the high prevalence of keywords and associated terms among Indian tweets during COVID-19. Further, this work clarifies public opinion on pandemics and lead public health authorities for a better society.

Keywords: COVID-19; sentimental analysis; word cloud; BERT; lockdown

Citation: Chintalapudi, N.; Battineni, G.; Amenta, F. Sentimental Analysis of COVID-19 Tweets Using Deep Learning Models. *Infect. Dis. Rep.* **2021**, *13*, 329–339. https://doi.org/10.3390/idr13020032

Academic Editor: Nicola Petrosillo

Received: 8 March 2021
Accepted: 30 March 2021
Published: 1 April 2021

1. Introduction

The COVID-19 pandemic has prompted a sensational loss of human life worldwide and presents an extraordinary challenge to global health, food systems, and the work universe [1]. The monetary and social disturbance is demolishing by this pandemic. Many people are in danger of undernourishment, and it could increment by up to 132 million before the end of 2020 [2,3]. The dynamics of COVID-19, including the mortality, contagion factors, time of country virus, and initial deaths, were presented by the responsive differences between social media and financial markets from the after-effects of the severe virus spread [4].

The world that we knew up to this point has been changed and these days we live in a new situation in a never-ending transformation progress, in which how we live, relate, and speak with others has been modified for all time [5]. Inside this specific circumstance, virus risk is assuming a definitive job when educating, sending, and diverting the progression of data in the public arena. Coronavirus has represented a genuine pandemic risk and a broad challenge regarding control, readiness, reaction, and improvement by governments, wellbeing associations, stakeholders, and media broadcasting [4,5].

The present crisis due to COVID-19 is creating a socially advanced situation that is exceptional for health communities [6]. We are living in an exceptionally globalized world, where relocation adaptability, free travel among nations, and the turn of events and utilization of Information and Communication Technologies (ICTs) are essentially developed [7]. We should feature the developing interconnection between the world's economies, which is reflected in the financial progress and individual knowledge [8].

Similarly, because of this virus outbreak, plenty of fake news and criticism on movements is continuously appearing on social media platforms. It disturbs communication among public health authorities and provokes high tension in the general public [9]. The study on social network analysis of novel virus sentimental analysis resulted in five relevant themes that range from positive to negative [10]. In this work, we considered the large dataset of tweets by Indian social media users. To do this, we defined a fine-tuned 12-layer Bidirectional Encoder Representations from Transformers (BERT) model, which is the latest deep-learning model for the analysis of textual data. The adoption of machine leering (ML) algorithms like logistic regression (LR), support vector machines (SVM), and single-layered LSTM (long-short term memory) models were done to compare the model performance with BERT. Based on this, this research work tries to answer the following research questions (RQ).

RQ1: What are the popular keywords that appeared in Indian tweets?

RQ2: How did these tweets affect public health systems?

RQ3: How do ML algorithms help to analyses people's emotions or sentiments?

RQ4: How far can deep-learning 12-layer BERT model outperform the other three conventional ML models?

The rest of the paper was organized as follows: the materials and methods are presented in Section 2; experimental outcomes are presented in Section 3. Discussion and conclusions are explained in Sections 4 and 5, respectively.

COVID-19 Studies Related to Social Media Fake News

The increment in false propaganda via online sites is turning into a global issue. In spite of the fact that fake news is not vital, but it is currently troubling a result of online media prominence that provides cooperation and dissemination of novel ideas [11]. The situation of the COVID-19 epidemic shows the valuable effects of the origination of new data. The false data spreading can clearly impact individual mindset and change the viability of the countermeasures conveyed by governments [12].

The mis-information on social media can create panic and anxiety among COVID-19 patients, consequently alarms local governments and public authorities to urge citizens to confirm the genuineness of circulating stories [13]. Some studies presented about information accuracy and people's behaviour in dealing with social media news associated with the COVID-19 pandemic [14–16]. The information diffusion of COVID-19 with big data analysis on major social media platforms presented an individual assessment of the address on a large scale to provide an exploration of epidemic rumours [17].

Twitter is a famous social media platform and microblogging medium where people post and share messages called "tweets". About 500 million tweets per day and 200 billion tweets per year have appeared on Twitter since it has become an important data hotspot for web-based media conversation identified with public and global situations [18]. Unfortunately, it also a major source to create a global panic situation because of spreading fake news. Chakraborty K et al. 2020 described that most COVID-19 tweets are in positive sentiment, but users are frequently engaged in the spreading of negative tweets and not many useful words were found in the word frequency calculation of tweets [19].

In some words of Shadi S et al. 2020, the present pandemic creating rapidly spread rumours and conspiracy theories is like a virus that leads to real world dramatic values [20]. The authors of this work present machine learning approaches for automatic detection and identify narrative frameworks in support of such false propaganda. It is also studied that the effects of misleading the COVID-19 information and its political ideology that ultimately poisoned the public health [21].

The observations from the Nigerian study of the social media impact of COVID-19 pandemic reported platforms like Twitter, Facebook, and YouTube, which cannot be overemphasized with a plan of action for data dispersal. It indicates that these platforms have been manhandled as individuals cover-up under its secrecy to spread fake news and affect alarm among individuals from the overall population [22]. In high-population countries like India, it is even worse in spreading fake news online, which could be a potential threat to public health. On 24 March 2020, India declared a nationwide lockdown and alarmed public health experts to manage the challenges of COVID-19. However, these works do not address the accuracy and validation of tweets to a large extent.

In response, the study on social media false propaganda on COVID-19 during the lockdown time found the seven themes of fake news, including health, political, crime, entertainment, religious, religiopolitical, and miscellaneous, by analysing 125 Indian fake news [13] examples. There was work conducted by Bakur G et al. (2020) on sentiment analysis of Indian people during the national lockdown. The dataset used in this analysis contains very few tweets from 25 March 2020 to 28 March 2020. Results portrayed the positive strategy of the Indian government for imposing lockdown [23].

Huynh 2020 reported that plenty of rumours and fake stories are circulating in social media on COVID-19 and it is getting difficult to differentiate this false news from real news, but the accuracy or validity has not been questioned [24]. The validation and accuracy of such fakes on social media sites can help people, healthcare staff, and governments from unnecessary mental pressure. Such procedures give an overall clarification to in any case of unexceptional events, and fits conveniently into the perspective of the conspiracy theories. Therefore, to fill this research gap among literature on the tweet validation, we attempted deep-learning type machine-learning models, and also validate this model performance by comparing with another three conventional models.

2. Materials and Methods

2.1. Dataset

In this study, we incorporated the data of Indian user tweets from the Twitter website during the COVID-19 lockdown period in-country. The data set consisting of 3090 tweets were extracted from github.com (https://github.com/gabrielpreda/CoViD-19-tweets (accessed on 12 January 2021)) and it contains the cleaned tweets on topics such as COVID-19, coronavirus, lockdown, etc. The dataset consisting of extracted tweets from the Indian twitter platform was considered for analysis. The contained tweets focused on the topics of COVID-19, coronavirus, and lockdown, etc.

2.2. Data Analysis

Figure 1 presents the distribution of the tweets collected on the dates between 23 March 2020 and 15 July 2020, and the text has been labelled as fear, sad, anger, and joy. The given sample tweets are manually coded as four category sentiments by the investigators and each sentiment is mapped from 0 to 3 (fear:0, sad:1, anger:2, and joy:3). Examples of tweets presenting the sentiments had displayed in Table 1. The positive sentiments consisted of words "thank", "well", "great", "agree", "admit", "good", etc. and negative sentiments consisted of words "die", "shit", "trump", "kill", "spread", "death", etc.

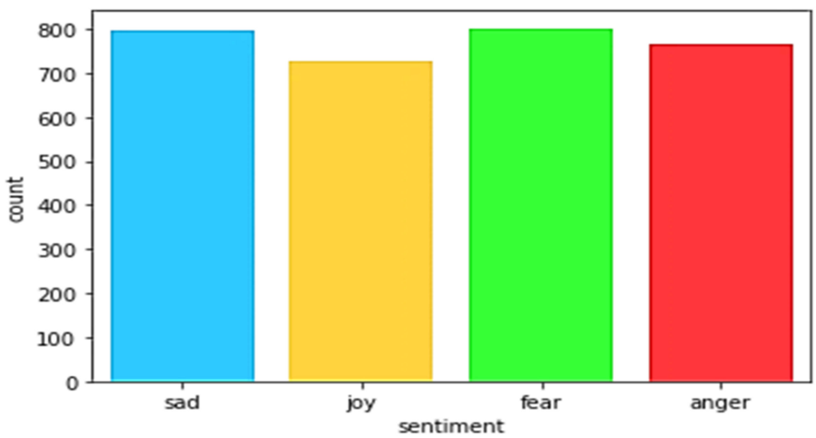

Figure 1. Tweets' sentiment distribution.

Table 1. Sample tweets that express sadness, joy, fear, and anger sentiments on COVID-19.

Sad Sentiments	Joy Sentiments	Fear Sentiments	Anger Sentiments
# agree on the poor in India are treated badly their poor seek a living in Singapore and are treated like citizens they are given free medical treatment given food daily sim cards to call home to tell their family that they are fine if CoViD-19 case treated for in hospitals # I do not understand the point of demanding enough time before lockdown Italy has suffered because of half-hearted attempts and so is us now pm being the highest decision-making authority has to take the decision # UK records lowest daily virus death toll since the start of lockdown govt # because of CoViD 19 guidelines restricting visitation to hospitals and care centres john could not see his father in person before he died now, he is asking members of his community to donate I-pads that will be distributed to local medical centres	# good morning twittizens wish you a corona free day # finally accepts thanks to Modi media # how ted-ed is helping family's students and teachers navigate the COVID-19 pandemic # the hardship of lockdown comes with the ease of blessing that Allah has brought family member together with my son asim town Punjab Pakistan # hoping that I would emerge on the other side of this healthier and more fit here's my dinner salad # brother's day 69 of lockdown from the archives of 2015 majnu ka tila (I'm normally lazy when it comes to archiving my photos and also the daily grind hinders the process but this lockdown boredom has given	# hackers use fake coronavirus maps to infect visitors with malware # I bet the idiot GB being is very concerned over the coronavirus not because of the health of their followers but because of the hit their bank account is going to take if meetings and assemblies are cancelled this is a worst-case scenario for them # when scares end # the thought of Jacob's Nashville show getting cancelled makes my heart hurt soooooo bad please go away # is the making you afraid of what the future holds looking for a sense of peace call 877 why Islam you deserve to know	# maybe if I bolt my front door shut coronavirus will stay out # there are no injections for handle girls do not trust your bf # so, you no longer think that the coronavirus is a hoax perpetrated by the democrats exactly when was your epiphany moment # the Christian right and are the biggest threat to the world right now during this pandemic they outright evil their ignorance is death incarnate

We applied natural processing techniques (NLP), which are a form of ML that help tweet processing. Usually, NLP involves several text mining approaches, such as noise removal, by excluding stop and buzz words [25]. To enhance the BERT model performance measurements, immaterial substances, or text noises like accentuation marks, mathematical qualities, new-line characters were eliminated. Removing these elements moderates the size of the test space of conceivable capabilities and therefore improves the degree of execution.

As mentioned, to use pre-trained text weights in the BERT model, we have to configure the input features with encoding. This particular model works with fixed lengths, and we applied a maximum length of 100 tokens. The token length of all the tweets has been depicted in Figure 2. A high number of tweets is under 100 tokens.

2.3. Data Partitioning

To confirm, the classification model cannot be overfitting on the dataset. We divided the dataset into two portions such as training and testing. Trained tweets are helping to identify the data patterns, also reducing error rates, and testing the data set used for the assessment of model performance. Of the tweets, 85% were used for training purposes and 15% of tweets were used for testing purposes. The demographic information of tweets classification is presented in Table 2.

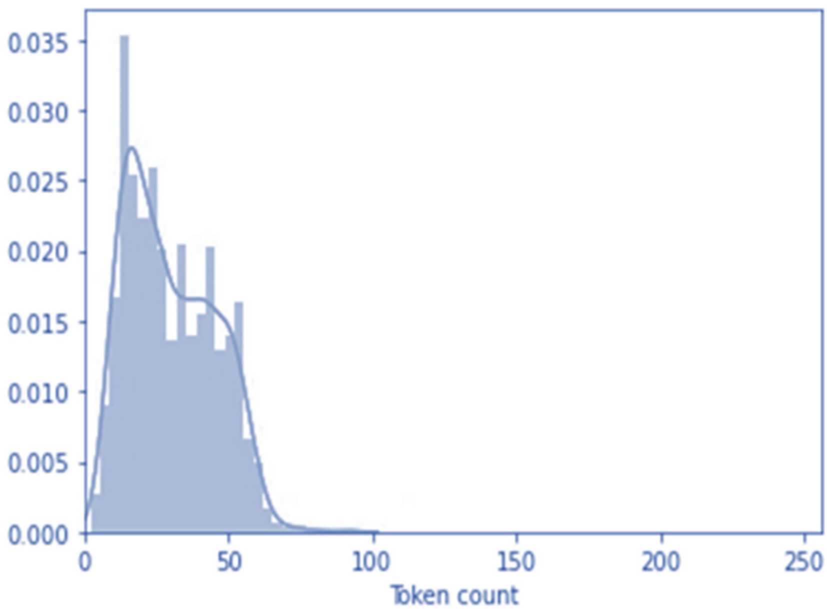

Figure 2. Tweets' token length outcome.

Table 2. Demographic representation of tweets classification.

Sentiment	Label	Data Type	
Fear	0	Training	723
		Validation	128
Sad	1	Training	680
		Validation	115
Anger	2	Training	652
		Validation	115
Joy	3	Training	618
		Validation	109

2.4. BERT Model

We implemented the BERT model for classifying the fake tweets. BERT is a new language presentation tool that stands for Bidirectional Encoder Representations from Transformers and was introduced in paper [26]. BERT has created a disturbance in the Machine Learning people group by introducing best in class, bringing about a wide assortment of NLP assessments. BERT's key specialized advancement is applying the bidirectional preparing of Transformer, a mainstream consideration model, to language demonstrating. This is an advanced form, past advancements that took a look at text sequencing either from left to right or right to left and combined the left to the right model. The results from paper [26] explained that a language model that is bi-directionally prepared can have a more profound feeling of language setting and stream than single directional models.

2.4.1. Model Training

In contrast to directional models that enable sequential reading of text input (right to left or left to right), the transformer encoder recognizes the total sequence of words at once. Thus, it is considered bidirectional, but it is a non-directional model with higher accuracy than other established models. This special characteristic allows the model to understand the text context. BERT has two models called the base model of 12 encoders and a large model of 24 encoders.

Model training in BERT has been completed by 15% tokens of input text language, which was randomly selected. These tokens further pre-processed by 80% are supplanted with a "MASK" token, 10% with an irregular word, and 10% utilize the first word. If we utilized "MASK" 100% of the time, the model would not delivers great symbolic portrayals for un-masked words. The un-masked tokens were as yet utilized for text setting, yet the model was upgraded for foreseeing masked words.

2.4.2. Prediction of the Next Sentence

In BERT training, the model collects statement pairs as input and figures out how to anticipate if the second sentence in the pair is the resultant sentence in the original file. In training, half of the data sources are a pair where the subsequent sentence is the resulting sentence in the first archive, while in the other half an irregular sentence from the corpus is picked as the subsequent sentence. The supposition will be that the irregular sentence will be detached from the primary sentence.

The input source to BERT is the sum of the token, segment, and position embeddings. To assist the model to differentiate sentence pairs in training, input has processed as mentioned below.

- ➢ A (CLS) token is embedded towards the initial statement and a (SEP) token is embedded toward the finish of each sentence.
- ➢ A statement embedding demonstrates the Sentence A or Sentence B can be added to every token. Sentence embeddings are comparable in idea to token embeddings with a second statement vocabulary.
- ➢ A positional inserting is added to every token to show its situation in the succession.

Word piece tokenization has been done by the BERT tokenizer: vocabulary displayed discrete characteristics of the language, and high-frequency vocabulary combinations repeatedly added. Keywords in Indian tweets were assessed by a word cloud diagram. Data was spitted into two subsets for training and validation purposes. Accuracy was further calculated to estimate the model accuracy.

2.5. Model Evaluation

To evaluate the efficiency of the BERT model, another three conventional models, such as LR, SVM, and LSTM, were further considered. LR is a kind of binary classification ML algorithm. It uses the weighted combination of the input text features and is authorized by the sigmoid function [27]. This function changes any real numerical input that ranges from 0 to 1. Instead of calculating the total number of words in a text document, we used T_f-I_{df} (term frequency–inverse document frequency) for normalizing the words into a number. It estimates normalized count, such as the count of each word that is divided by a total number of documents, where the same word appears. We applied a similar ratio of dataset distribution (85:15) as followed in BERT modelling. SVM is another ML classification algorithm based on the identification of hyperplanes defined by data classes [28]. It operates on large data sizes and calculates the separation of data margin rather than matching key features. The similar approach of 85% of tweets is used for SVM model training.

Alternatively, we used the LSTM model, which is a type of recurrent neural network (RNN). LSTM network models are a sort of intermittent neural organization that can learn and recollect large information groups. They are expected for use with information that is contained in the long sequence of input data, up to 200 to 400-time steps [29]. That is why we considered LSTM as one of the accepted models for text analysis. The model can uphold various parallel information sequences and figures out how to remove features from data sequences. Like BERT, this model also trained by AdamW optimizer.

3. Results

The word cloud is a visual representation of words that usually appeared in texts. Figure 3 presents the word cloud of the Indian tweets' dataset, and Figure 4 presents the top 50 keywords presented in Indian tweets.

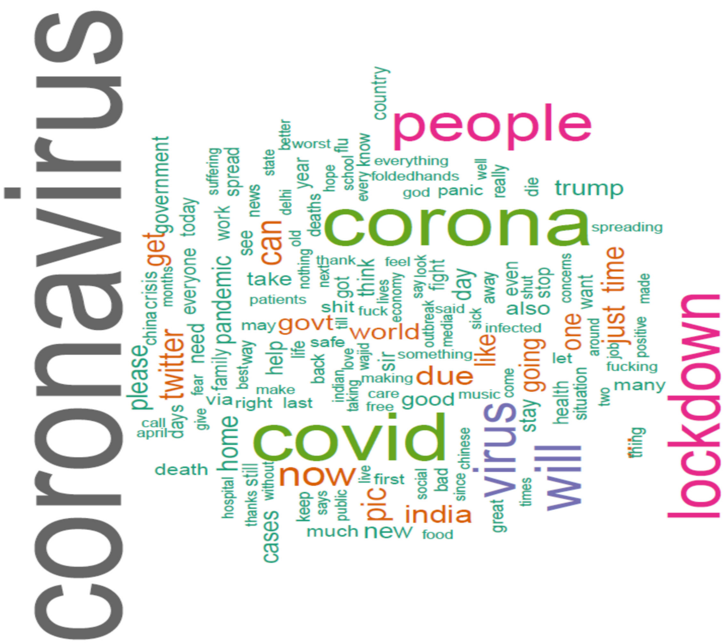

Figure 3. Word cloud of common words in Indian tweets.

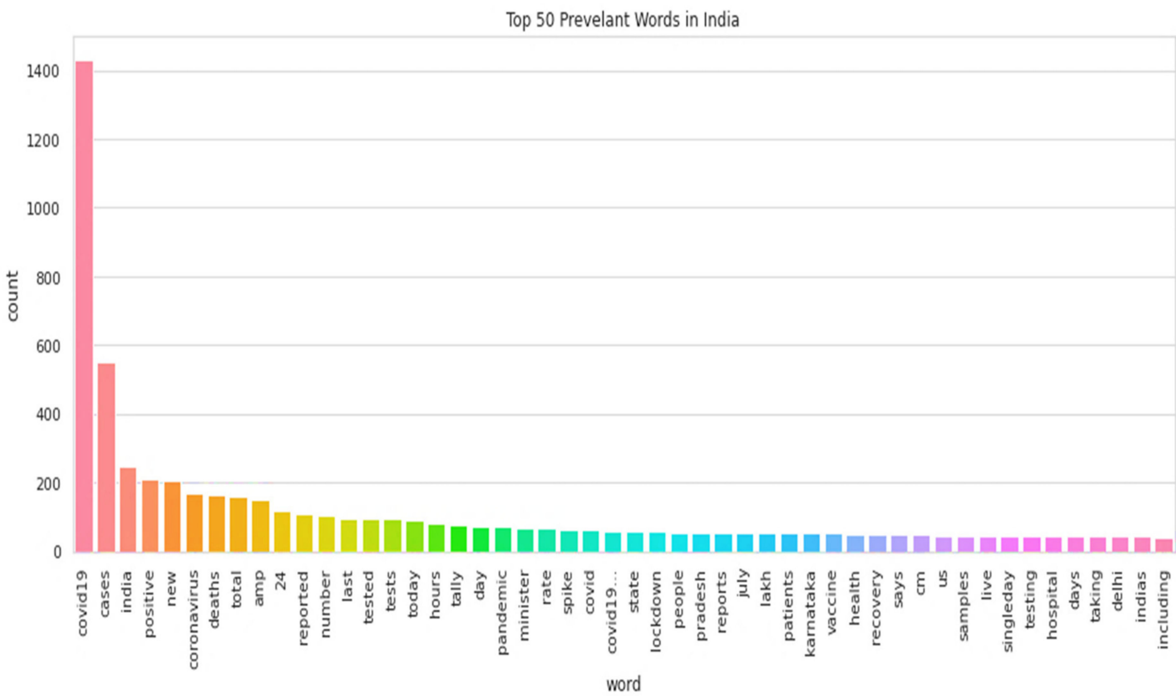

Figure 4. Top 50 keywords that appeared in Indian tweets.

For model performance evaluation, accuracy was considered the primary parameter. For fine-tuning and to duplicate the training features, we adopted the AdamW optimizer and applied the Adam algorithm by weight decay. Because of model training with the individual stage (or Epoch), training accuracy has resulted. The outcome test loss on a given test dataset has appeared as 0.594 and test accuracy appeared as 0.890, which presents that the model can generalize the tweets in a good manner. The model with 89% accuracy itself proved as a better solution in tweets classification. Table 3 presents the accuracy comparisons of four evacuated models.

Table 3. Accuracy comparisons of four models.

Model	Accuracy (in %)
Fine-tuned BERT	89%
LR	75%
SVM	74.75%
LSTM	65%

The prediction accuracy of each sentiment tweet has been separately calculated by dividing sentimental data into training and validation sets. The mentioned tweets are fed as input for the model for training and the accuracy of each investigated sentiment has been assessed. The predicted accuracy values of each sentimental outcome can be observed in Table 4.

Table 4. Sentiment tweet distribution for model training.

Sentiment	Label	Data Type		Valid Tweets	Accuracy
Fear	0	Training	723	107	85.60%
		Validation	128		
Sad	1	Training	680	96	83.40%
		Validation	115		
Anger	2	Training	652	91	79.13%
		Validation	115		
Joy	3	Training	618	83	76.14%
		Validation	109		

4. Discussion

The spread of pandemics causes vulnerability and anxiety among the global population. This sort of emergency, by not changing following explicit cut-off points, makes risk communication basic when planning to do better prevention strategies. If effective risk communication has been implemented, there is a chance of delivering messages to the public transparently and effectively. The key objective behind this is to diminish the knowledge gap between data investigators and recipients in understating public behaviour to fight against the pandemic. The fundamental components for risk reduction and anxiety assessment among the population are by taking rapid action from public health authorities and genuine data from governments.

Sentiment analysis majorly helps to understand people's emotions in a particular event. Sentimental tweets about the pandemic have bound to be positive, suggesting that the public stayed confident despite a remarkable public wellbeing emergency. Keywords of positive sentiments normally communicated appreciation for community efforts and front-line workers to support vulnerable individuals of society, however, some keywords passed on negative opinions towards those who are at the frontline. A few words are attracted to joyful statements that can encourage doctors for fighting the war against COVID-19. Another type of positive estimation was the support of contamination measures to keep up general wellbeing guidelines like "stay safe", "remain home" patterns.

India is the second-high pandemic that hit the country after the USA with 11.5 million infected cases and third position in deaths with a total of 160,427 [30]. The sentiment analysis of Indian tweets during COVID-19 lockdown obtained in this study have produced interesting results and presented the importance of further validation and experimental model advancement with more COVID-19 data, and supplementary methods. Models were subsequently created with extra information and strategies and utilizing BERT model tweet classification techniques would then be able to be utilized as self-governing techniques for autonomous classification of COVID-19 sentiment. The proposed model and results also similarly extended country-wise and global pandemic experiences in the future.

Recent trends in NLP suggest that text mining has increased its popularity in the advancement of big data analysis augmented computational competencies, and unstructured data analysis that enables the examination of huge linguistical datasets. The research presented in this paper with the use of the BERT sentiment analysis package in R produced a good exercise for evaluating the prediction accuracy of text outcomes. A similar analysis has been presented in [31] for the understanding of pandemic anxiety among Twitter users based on particular keywords. About 900,000 tweets are extracted from Twitter Application programming interface (API) and analysed using Naïve Bayes and logistic regression models. The model accuracy that appeared in short tweets is 91% and 74%, respectively. However, the main limitation of this study is all sentiments depend on the single word "fear" of USA citizens.

The study about precise ideas of netizens on the COVID-19 pandemic has identified twelve major topics that would emphasize sentiment topics and are highly related to health care problems [32]. Another interesting study on the mental health of Chinese youth for using Weibo messenger reported the most biased results. It highlighted negative sentiments in young minds during this outbreak [33]. In contrast, in this study, we highlighted four emotions of Indian netizens that associated both positive and negative sentimental categories. It is evident that from Table 3, the BERT model has outperformed the other three models in the classification of COVID-19 tweets. It produced 89% accuracy, which is much better than other models. Thus, it proves that the BERT model is the best solution for understanding the fake tweets while compared with other models. The present study has some limitations because it addresses only a single country of people's emotions on social media sites on present pandemic, therefore, the generalization to global perspective on pandemics should be done in future studies.

5. Conclusions

In conclusion, our findings present the high prevalence of keywords and associated terms among Indian tweets during COVID-19. Based on the contents, the tweets are classified into four sentiments such as fear, sad, anger, and joy. Some words like "trump", "kill", "death", "die" provoke people to have unnecessary fear and words such as "thank", "well", "good" create a positive setup in the healthcare authorities. These findings encourage local governments to impose fact-checkers on social media to overcome false propaganda. Previous literature only focuses on the effects of social media and its implications on the circulation of fake news but does not discuss the validation and classification of tweets. Thus, we applied a novel deep-learning model called BERT to achieve high classification accuracy in contrast to conventional ML models. Results provided enough evidence that the BERT model achieved 89% accuracy, which beats other models like LR, SVM, and LSTM. In this way, this work clarifies public opinion on pandemics and guides medical authorities, the public, and private workers to overcome needless anxiety during pandemics.

Author Contributions: N.C. and G.B.: Study design, research materials, data collection, manuscript preparation. N.C. and F.A.: The initial and final drafts of the article. All authors have read and agreed to the published version of the manuscript.

Funding: This paper was supported in part by the ITF Trust grant No. 1508/2020 to Centro Internazionale Radio Medico (C.I.R.M.).

Institutional Review Board Statement: This study does not need ethical statement.

Informed Consent Statement: Not applicable.

Data Availability Statement: The authors would like to thank the data investigators Gabriel P and Arushi C. The tweets data and code can be available at https://github.com/gabrielpreda/CoViD-19-tweets (accessed on 12 January 2021).

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chawla, S.; Mittal, M.; Chawla, M.; Goyal, L. Corona Virus-SARS-CoV-2: An Insight to Another way of Natural Disaster. *EAI Endorsed Trans. Pervasive Health Technol.* **2020**, *6*. [CrossRef]
2. Mertens, G.; Gerritsen, L.; Duijndam, S.; Salemink, E.; Engelhard, I.M. Fear of the coronavirus (COVID-19): Predictors in an online study conducted in March 2020. *J. Anxiety Disord.* **2020**, *74*, 102258. [CrossRef] [PubMed]
3. Socio-Economic Impact of COVID-19 | UNDP. Available online: https://www.undp.org/content/undp/en/home/coronavirus/socio-economic-impact-of-covid-19.html (accessed on 15 October 2020).
4. Staszkiewicz, P.; Chomiak-Orsa, I. Dynamics of the COVID-19 Contagion and Mortality: Country Factors, Social Media, and Market Response Evidence from a Global Panel Analysis. *IEEE Access* **2020**, *8*, 106009–106022. [CrossRef]
5. Donthu, N.; Gustafsson, A. Effects of COVID-19 on business and research. *J. Bus. Res.* **2020**, *117*, 284–289. [CrossRef] [PubMed]
6. Guo, Y.-R.; Cao, Q.-D.; Hong, Z.-S.; Tan, Y.-Y.; Chen, S.-D.; Jin, H.-J.; Tan, K.-S.; Wang, D.-Y.; Yan, Y. The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak—An update on the status. *Mil. Med. Res.* **2020**, *7*, 1–10. [CrossRef] [PubMed]
7. Mittal, M.; Battineni, G.; Goyal, L.M.; Chhetri, B.; Oberoi, S.V.; Chintalapudi, N.; Amenta, F. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. *Int. Marit. Health* **2020**, *71*, 213–214. [CrossRef] [PubMed]
8. Akande, O.N.; Badmus, T.A.; Akindele, A.T.; Arulogun, O.T. Dataset to support the adoption of social media and emerging technologies for students' continuous engagement. *Data Brief* **2020**, *31*, 105926. [CrossRef] [PubMed]
9. Garcia, L.P.; Duarte, E. Infodemic: Excess quantity to the detriment of quality of information about COVID-19. *Epidemiol. Serv. Health* **2020**, *29*. [CrossRef]
10. Hung, M.; Lauren, E.; Hon, E.S.; Birmingham, W.C.; Xu, J.; Su, S.; Hon, S.D.; Park, J.; Dang, P.; Lipsky, M.S. Social Network Analysis of COVID-19 Sentiments: Application of Artificial Intelligence. *J. Med. Internet Res.* **2020**, *22*, e22590. [CrossRef]
11. Di Domenico, G.; Sit, J.; Ishizaka, A.; Nunan, D. Fake news, social media and marketing: A systematic review. *J. Bus. Res.* **2021**, *124*, 329–341. [CrossRef]
12. Apuke, O.D.; Omar, B. Fake news and COVID-19: Modelling the predictors of fake news sharing among social media users. *Telemat. Inform.* **2021**, *56*, 101475. [CrossRef]
13. Zaman, A. COVID-19-Related Social Media Fake News in India. *J. Media* **2021**, *2*, 7. [CrossRef]
14. Depoux, A.; Martin, S.; Karafillakis, E.; Preet, R.; Wilder-Smith, A.; Larson, H. The pandemic of social media panic travels faster than the COVID-19 outbreak. *J. Travel Med.* **2020**, *27*, taaa031. [CrossRef] [PubMed]
15. Gao, J.; Zheng, P.; Jia, Y.; Chen, H.; Mao, Y.; Chen, S.; Wang, Y.; Fu, H.; Dai, J. Mental health problems and social media exposure during COVID-19 outbreak. *PLoS ONE* **2020**, *15*, e0231924. [CrossRef]
16. Ahmad, A.R.; Murad, H.R. The Impact of Social Media on Panic During the COVID-19 Pandemic in Iraqi Kurdistan: Online Questionnaire Study. *J. Med. Internet Res.* **2020**, *22*, e19556. [CrossRef] [PubMed]
17. Cinelli, M.; Quattrociocchi, W.; Galeazzi, A.; Valensise, C.M.; Brugnoli, E.; Schmidt, A.L.; Zola, P.; Zollo, F.; Scala, A. The COVID-19 social media infodemic. *Sci. Rep.* **2020**, *10*, 1–10. [CrossRef] [PubMed]
18. Twitter, Twitter Usage Statistics—Internet Live Stats. Available online: https://www.internetlivestats.com/twitter-statistics/ (accessed on 19 October 2020).
19. Chakraborty, K.; Bhatia, S.; Bhattacharyya, S.; Platos, J.; Bag, R.; Hassanien, A.E. Sentiment Analysis of COVID-19 tweets by Deep Learning Classifiers—A study to show how popularity is affecting accuracy in social media. *Appl. Soft Comput.* **2020**, *97*, 106754. [CrossRef] [PubMed]
20. Shahsavari, S.; Holur, P.; Tangherlini, T.R.; Roychowdhury, V. Conspiracy in the time of corona: Automatic detection of COVID-19 conspiracy theories in social media and the news. *J. Comput. Soc. Sci.* **2020**, *3*, 279–317. [CrossRef]
21. Havey, N.F. Partisan public health: How does political ideology influence support for COVID-19 related misinformation? *J. Comput. Soc. Sci.* **2020**, *3*, 319–342. [CrossRef]
22. Obi-Ani, N.A.; Anikwenze, C.; Isiani, M.C. Social media and the COVID-19 pandemic: Observations from Nigeria. *Cogent Arts Humanit.* **2020**, *7*, 1799483. [CrossRef]
23. Barkur, G.; Vibha; Kamath, G.B. Sentiment analysis of nationwide lockdown due to COVID 19 outbreak: Evidence from India. *Asian J. Psychiatry* **2020**, *51*, 102089. [CrossRef]
24. Huynh, T.L. The COVID-19 risk perception: A survey on socioeconomics and media attention. *Econ. Bull.* **2020**, *40*, 758–764. Available online: https://ideas.repec.org/a/ebl/ecbull/eb-20-00175.html (accessed on 26 March 2021).
25. Chintalapudi, N.; Battineni, G.; Di Canio, M.; Sagaro, G.G.; Amenta, F. Text mining with sentiment analysis on seafarers' medical documents. *Int. J. Inf. Manag. Data Insights* **2021**, *1*, 100005. [CrossRef]
26. Devlin, J.; Chang, M.W.; Lee, K.; Toutanova, K. BERT: Pre-training of deep bidirectional transformers for language understanding. *arXiv* **2018**, arXiv:1810.04805.

27. del Prette, Z.A.P.; del Prette, A.; de Oliveira, L.A.; Gresham, F.M.; Vance, M.J. Role of social performance in predicting learning problems: Prediction of risk using logistic regression analysis. *Sch. Psychol. Int.* **2011**, *33*, 615–630. [CrossRef]
28. Chang, Y.W.; Hsieh, C.J.; Chang, K.W.; Ringgaard, M.; Lin, C.J. Training and testing low-degree polynomial data mappings via linear SVM. *J. Mach. Learn. Res.* **2010**, *11*, 1471–1490.
29. Melamud, O.; Goldberger, J.; Dagan, I. Context2vec: Learning generic context embedding with bidirectional LSTM. In Proceedings of the 20th SIGNLL Conference on Computational Natural Language Learning 2016, Berlin, Germany, 11–12 August 2016. [CrossRef]
30. India—COVID-19 Overview—Johns Hopkins. Available online: https://coronavirus.jhu.edu/region/india (accessed on 23 March 2021).
31. Samuel, J.; Ali, G.; Rahman, M.; Esawi, E.; Samuel, Y. COVID-19 Public Sentiment Insights and Machine Learning for Tweets Classification. *Information* **2020**, *11*, 314. [CrossRef]
32. Abd-Alrazaq, A.; Alhuwail, D.; Househ, M.; Hamdi, M.; Shah, Z. Top Concerns of Tweeters During the COVID-19 Pandemic: Infoveillance Study. *J. Med. Internet Res.* **2020**, *22*, e19016. [CrossRef]
33. Li, S.; Wang, Y.; Xue, J.; Zhao, N.; Zhu, T. The Impact of COVID-19 Epidemic Declaration on Psychological Consequences: A Study on Active Weibo Users. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2032. [CrossRef]

healthcare

Review

Telemedicine for Pre-Employment Medical Examinations and Follow-Up Visits on Board Ships: A Narrative Review on the Feasibility

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Abstract: Background: Telemedicine has already been applied to various medical specialties for diagnosis, treatment, and follow-up visits for the general population. Telemedicine has also proven effective by providing advice, diagnosis, and treatment to seafarers during emergency medical events onboard ships. However, it has not yet been applied for pre-employment medical examinations and follow-up visits on board ships. Objective: This review aimed to assess the possibility of using telemedicine during periodic visits between one pre-employment medical examination and others on board ships, and to recommend necessary medical examination tests with screening intervals for seafarers. Methods: Various databases including PubMed, EMBASE, Scopus, CINAHL, and Cochrane Library were explored using different keywords, titles, and abstracts. Studies published between 1999 and 2019, in English, in peer-reviewed journal articles, and that are conference proceedings were considered. Finally, the studies included in this review were chosen on the basis of the eligibility criteria. Results: Out of a total of 168 studies, 85 studies were kept for further analysis after removing the duplicates. A further independent screening based on the inclusion and exclusion criteria resulted in the withdrawal of 51 studies that were not further considered for our analysis. Finally, 32 studies were left, which were critically reviewed. Out of 32 accepted studies, 10 studies demonstrated the effectiveness of the electrocardiogram (ECG) in monitoring and managing remote patients with heart failure, early diagnosis, and postoperative screening. In 15 studies, telespirometry was found to be effective in diagnosing and ruling out diseases, detecting lung abnormalities, and managing patients with chronic obstructive pulmonary disease (COPD) and asthma. Seven studies reported that telenephrology was effective, precise, accurate, and usable by non-medical personnel and that it reduced sample analysis times and procedures in laboratories. Conclusion: using new technologies such as high-speed internet, video conferencing, and digital examination, personnel are able to make the necessary tests and perform virtual medical examination on board ships with necessary training.

Keywords: telemedicine; seafarers; cardiology; healthcare; technology

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Citation: Sagaro, G.G.; Di Canio, M.; Talevi, E.; Amenta, F. Telemedicine for Pre-Employment Medical Examinations and Follow-Up Visits on Board Ships: A Narrative Review on the Feasibility. *Healthcare* **2021**, *9*, 69. https://doi.org/10.3390/healthcare9010069

Received: 4 December 2020
Accepted: 8 January 2021
Published: 13 January 2021

1. Introduction

Telemedicine is the delivery of medical services over distance through information and communication technologies [1]. Telemedicine applications include disease prevention and control, healthcare, health promotion, education, training, and research for health [1]. Telemedicine can be traced back to the end of the 19th century to the mid-20th century with the use of radiotelegraphy to provide medical advice to patients onboard ships [2]. The evolution versus modern telemedicine began in the 1960s, mainly spurred on by the military and space technologies, as well as by some people using readily available commercial equipment [3,4]. More recently, the applications of telemedicine are manifold and involve both developed and developing countries, rural areas, islands, and in all situations where distance could limit or make difficult the provision of medical care [5].

Merchant ships represent one of these potential scenarios as they spend long periods on the high seas. Most of the time, merchant ships do not carry a doctor or other health professional on board, and the healthcare is in the hands of the captain or his delegate when seafarers are injured or ill [2,6]. Seafaring is a hazardous profession when compared to land workers [7]. This is probably due to the intrinsic nature of the work rich in psychophysical stressors, including isolation from the family, the multiculturalism of the crews, limited recreational opportunities, and long work shifts [8]. Seafarers exhibit high mortality and morbidity when compared with workers onshore for both the deck and machine sectors [9]. They are also prone to unhealthy lifestyles, such as smoking and unhealthy diets [10]. These risk factors, combined with chemical exposure, make seafarers one of the categories with the highest rate of certain cancer and cardiovascular diseases (CVD) [8]. The most frequent causes of death are attributable to shipboard accidents, work-related accidents, CVD, and poisonings [11,12].

Occupational medicine is an internationally recognized branch of preventive medicine with a large diffusion in all EU countries with the broad spectrum of its influence. One of the main objectives of occupational medicine is the assessment of suitability or unsuitability for a given work, temporary or permanent. Moreover, occupational medicine has the task of assessing the risks associated with the workplace to protect and promote people's health by preventing diseases and accidents that could occur in the workplace [13]. In terms of telemedicine applications to occupational medicine, more than 50% of hospitals in the USA are using telemedicine to treat their patients and over 74% of companies offer telemedicine services to their employees as a part of their healthcare programs [14,15]. Moreover, in the UK, telemedicine is widely used and booming [16]. Telemedicine is often used in postoperative clinical programs and in the follow-up of patients with chronic diseases such as diabetes [17]. Telemedicine is widely demonstrated in the literature in many medical specialties such as pediatrics, neurology, cardiology, diabetology, psychiatry, postoperative orthopedic care, primary care, and emergency medicine in cognitive disorders [18–25]. However, only a few studies have focused on the use of telemedicine in maritime occupational medicine, especially virtual medical examination/test application during emergency on board ships.

The World Labour Organization (WLO) and the International Maritime Organization (IMO), in the report "Guidelines on the medical examination of seafarers", published recommendations concerning pre-employment medical examinations (PEME). The purpose of the PEME is to reduce the risk of illnesses or injuries to the seafarer on board. These visits are carried out every two years and involve certain tests proposed by the WLO and the IMO [26]. Protocols for pre-employment medical examination developed by national maritime authorities or other insurers, agents, or private companies may change screening intervals of less than the expected two years, some of which are carried out directly on board ships [10].

In Italy, the regulations in force provide that a competent doctor, appointed by the shipowner, within the framework of a health protocol, adequately monitors the health conditions of seafarers by carrying out periodic visits. Different medical tests are taken into account during each visit (health check at the time of recruitment/first visit and periodic check-ups), and medical examinations are considered, such as blood chemistry tests, electrocardiogram (ECG), visual function examination, audiometry, and other tests on doctor's recommendation, particularly during periodic visits. The legislation requires the competent doctor to collaborate with the employer/shipowner and/or the captain and with his prevention and protection service in order to carry out preventive and periodic health checks, expressing suitability for the specific task. The competent (occupational) doctor is also called upon to establish the health records of the individual worker, communicating any aptitude in writing to the employer/owner and to the worker [27–29]. However, there are lengthy processes for a medical check-up before boarding services; shipowners' requests are addressed to the SASN (Servizi Assistenza Sanitaria Naviganti)-Health Assistance Services for Navigation, Maritime and Civil Aviation Personnel, reference USMAF-SASN for the territory or to an authorized medical officer [30]. After approval, depending on the appointment, periodic medical check-ups are to be carried out, with most medical examinations being performed onboard ships by a doctor or other health professionals. Hence, telemedicine for periodic medical check-ups can reduce unnecessary travel, skip/shorten some process steps, reduce transport costs for regular check-ups, avoid waiting lists, and increase the quality of services by offering specialty doctors the opportunity to participate in virtual examinations.

Telemedicine has proven effective by providing advice, diagnosis, and treatment to seafarers during emergency on board ships [31]. It has already been applied to various medical specialties for diagnosis, treatment, and follow-up visits for the general population and has made it possible to overcome various constraints such as geography and the resources to provide healthcare to remote populations [32]. However, it has not yet been used for pre-employment medical examinations and follow-up visits onboard ships. The purpose of the present review was to assess the possibility of using telemedicine during periodic visits between the pre-employment medical examination and others and to propose necessary medical tests with screening intervals to be included in PEME protocols.

2. Materials and Methods

The review was conducted by searching the different published scientific literature, indexed in various databases, including PubMed, EMBASE, Scopus, CINAHL, and Cochrane Library. We included studies in areas of 4 medical specialties reporting medical exams/tests frequently used in telemedicine, namely, electrocardiogram (ECG), spirometry, blood glucose monitoring, and urinalysis. Different key terms for search, including "telecardiology", "tele diabetology", "telespirometry", "telenephrology", "teleconsultation", "telemedicine", and "telehealth" were used. Inclusion criteria for selected studies included studies published between 1999 and 2019, studies published in English, peer-reviewed journal articles, conference proceedings, and full-text paper. Studies published with only abstracts and not in English were excluded.

In total, 168 potentially relevant studies were selected from the above databases. Out of a total of 168 relevant studies, 85 studies remained after the duplicates were removed. A further 51 studies were excluded upon reviewing the abstract, title, and assessment of full-text as not consistent with our research questions. Finally, 32 studies were selected after a thorough review and included in this review (Figure 1). The review analysis involved 3 independent reviewers and an expert in the event of disagreement.

The summary of results for the application of telemedicine in various medical examinations/tests of occupational medicine interest is summarized in Table 1 (Table 1).

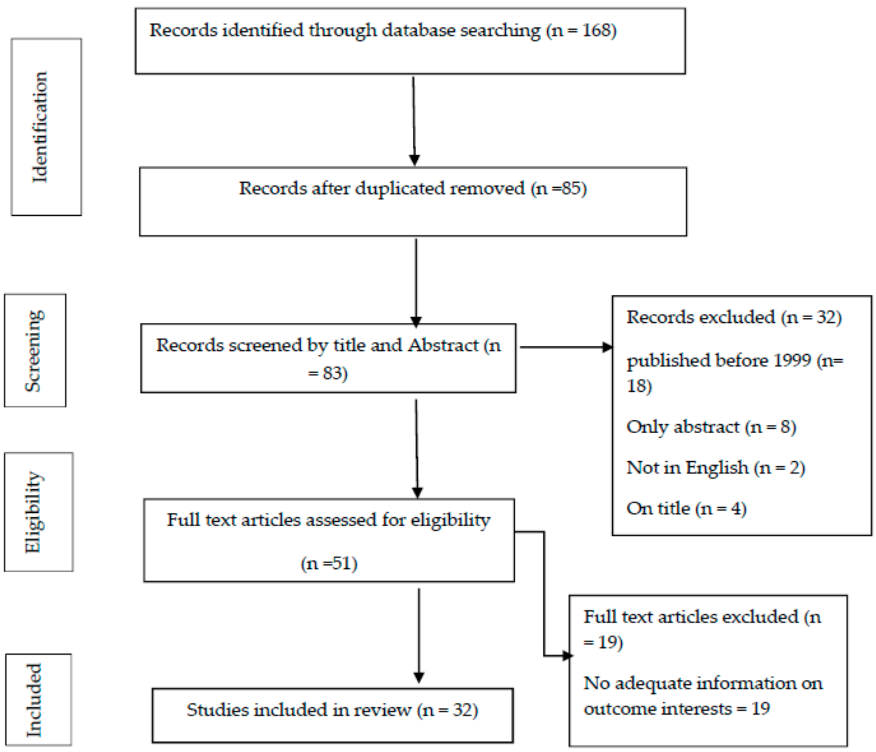

Figure 1. Literature search flowchart with eligibility criteria.

Table 1. Summary of results for the application of telemedicine in different medical examinations/tests.

Area of Application	Medical Examination/Test	Purpose of Application	Outcome	Reference(s)
Telecardiology	Electrocardiogram (ECG)	For tele-transmission and teleconsultation in the management of remote patients with heart failure Telemonitoring and postoperative screening of patients with cardiovascular cases Prevention screening	✓ Reduction of costs for diagnosis; ✓ Accurate in detecting an episode of atrial fibrillation (93%) and examination (94%). ✓ Effective remote patient monitoring, including early diagnosis and postoperative screening.	Molinari G. et al. [33] Inglis S.C. et al. [34] Lin C.T. et al. [35] Ong M.K. et al. [36] Herrin J. et al. [37] Majumder S. et al. [38] Sohn S. et al. [39] De Lazzari C. et al. [40] De Lazzari C. et al. [41] Lupi, L. et al. [42]
Telespirometry	Spirometric test	Respiratory function test For early diagnosis and management of patients with COPD, asthma	✓ Effective by diagnosing and rule out pathologies, detecting pulmonary abnormalities. ✓ Successful self-management of clinical parameters of patients at home. ✓ Effective in managing patients with COPD and asthma (97.32% diagnosing accuracy).	Kim et al. [43] Zealand N. [44] Molina-bastos C.G. et al. [45] Averame G. et al. [46] Toledo P.D. et al. [47] Owens M. et al. [48] Jouneau S. et al. [49] Vitacca M. et al. [50] Ohberg F. et al. [51] Kupczyk M. et al. [52] Redlich C.A. et al. [53] Stout J.W. et al. [54] Fung A.G. et al. [55]

Table 1. *Cont.*

Area of Application	Medical Examination/Test	Purpose of Application	Outcome	Reference(s)
Tele-diabetology	Blood glucose monitoring	Remote glycemic self-monitoring. Telenursing, personal medical records, and tele-transmission.	✓ Effective in diagnosis, treatment, self-glycemic monitoring, and follow up.	Bruttomesso D. et al. [56] Rodriguez-Gutierrez R. et al. [57]
Telenephrology	Urinalysis	Diagnosis and monitoring of the subject's nephrological and urological conditions. Prevention screening.	✓ Reduction of time of sample analysis and procedures in laboratories. ✓ Effective, precise, accurate, and usable by non-medical personnel. ✓ Successful in analyzing various tests, including glucose, proteins, bilirubin, ketones, nitrites, pH, specific gravity, erythrocytes, and leukocytes. ✓ The device is efficient and inexpensive.	Hannemann-Pohl K. et al. [58] Langlois M.R. et al. [59] Mohammadi S. et al. [60] Ginardi R.V.H. et al. [61] Lee D.S. et al. [62] Soldat D.J. et al. [63] Montangero M [64]

3. Telemedicine in Different Medical Examinations/Tests

3.1. Electrocardiogram (ECG)

Telemedicine is not a separate medical modality but includes a growing variety of applications and services that use telephone lines, videos, e-mails, smartphones, wireless tools, and other forms of telecommunication technology. Among the wide range of medical specialties in which telemedicine has been successfully applied, cardiology has been found to be one of the most common fields of application. Through the transmission of clinical data and the electrocardiogram (ECG), telecardiology allows access to a real-time assessment (teleconsultation) without the need to travel for both the patient and the cardiologist. Telecardiology has proven to be useful in the clinical management of remote patients with real or suspected heart disease in different clinical settings. Over 20 years, several attempts have been made to try to introduce and expand telecardiology in the hospital setting, especially for the diagnosis and treatment of patients in remote locations [33]. Positive impacts of telecardiology have been demonstrated in the literature on patients with heart failure. In these patients, remote monitoring compared to traditional monitoring procedures decreased the risk of recurrence of the event [34].

A study conducted in 2010 demonstrated that the accuracy of an ECG performed remotely via wireless procedures in detecting an episode of atrial fibrillation was 93%, and the accuracy of this examination was 94% [35]. A study by Ong et al. (2016) focused on the effectiveness of remote patient monitoring (RPM) for the transition of care in adult patients with heart failure, finding no significant difference in patient readmissions for 180 days. Those who received the remote monitoring intervention had readmission rates of 50.8%, while those who did not receive the intervention had readmission rates of 49.2% [36]. Another study compared hospital readmission rates and death rates for two groups of heart failure patients, followed by telemonitoring and conventional monitoring. The types of post-treatment screening were comparable in that no statistically significant difference was found. Readmission rates were 49.3% for remote monitoring and 47.4% for routine care, while the mortality rate for remote monitoring was 11.1%, and in routine care it was 11.4% [37].

The use of portable, non-invasive tele-cardiologic screening equipment was found to be less costly for hospitals and more comfortable for patients, allowing them to remain in domestic environments [38]. According to Sohn, costs would be around 25% lower in patients with mild symptoms [39]. In addition, to diagnosis and postoperative screening, telecardiology can also be used in prevention. In 2010, an Italian project was launched aimed at using a telecardiology device to perform early diagnosis of 13,016 students aged 16 to 19 [40]. In 2016, the same author collected the results showing that 24% of the suspects had altered signals in the electrocardiogram. The conclusion was that the use of telecardiology procedures in mass screening has many advantages such as lower costs, the possibility of use in environments far from hospitals, and not requring qualified personnel [41]. Another study evaluated the effectiveness of remote monitoring through the use of various devices, including the electrocardiogram (ECG) in healthy clients, in patients at risk for cardiovascular diseases such as those with diabetes and hypertension, and in patients with a previous cardiovascular event. The healthy clients were monitored by a 12-lead ECG installed in pharmacies and connected to a telemedicine platform manned by a cardiologist 24 h a day. Between 1 January 2015 and 31 December 2017, the study involved a total of 79,898 women (mean age 52 $\pm$ 12 years) and 68,458 men (mean age 49 $\pm$ 11 years). Of all ECGs performed, approximately 8% showed electrocardiographic abnormalities inconsistent with the patient's medical history. The authors confirm that tele-cardiological screening systems can be used successfully in the prevention of cardiovascular diseases with a consequent positive impact on public health [42].

3.2. Spirometry

Spirometry, also defined as spirometric test or simply respiratory function test, is a diagnostic test that is performed using a spirometer, a computerized instrument, connected to a mouthpiece. It is a very simple, painless, and non-invasive examination. Spirometry plays an important role in the diagnosis and monitoring of chronic obstructive respiratory disease. It should be noted that relevant clinical guidelines indicate the need for widespread use of spirometry in primary care for the early diagnosis and appropriate management of chronic asthma and chronic obstructive bronchopulmonary disease (COPD). Hence, this test is of relevant importance in the health surveillance in preventive medicine for seafarers who, for working reasons, often need to face long journeys [43,44]. The possibility of remote use of spirometry through telemedicine equipment has been investigated by several authors both as a prevention and monitoring tool in patients suffering from respiratory syndrome [45]. Telespirometry is used in clinical practice to monitor asthma patients and patients with COPD living at a distance from the hospital [46,47]. These integrated systems, in patients with respiratory diseases and frequent exacerbations, can reduce both emergency room visits and the number of hospitalizations [48].

In 2009, Bonavia published an article reporting an Italian project investigating the possibility of using telespirometry in general medicine. As a part of the project, 937 family physicians exchanged data via telespirometry equipment with 56 specialist centers, visiting their patients with risk factors, persistent respiratory symptoms, or a previous diagnosis of asthma or chronic obstructive pulmonary disease for two years. About 90% of the spirometry tests (20,757 spirometry tests performed in total) met the criteria and made it possible to make a diagnosis or rule out pathologies. 40% of the spirometries made it possible to detect pulmonary abnormalities. The authors consider telespirometry to be a reliable and useful alternative in the management by general practitioners of chronic respiratory diseases. The quality of the spirometric examination is highly dependent on the skills of the technician administering the test. The pulmonology company's guidelines indicate the skills and training to be acquired to manage this exam [49]. An interesting perspective, which involves several studies, is given by the possibility of remote monitoring at home. This technology enables the self-measurement of clinical parameters/symptoms of patients at home and allows the communication between healthcare professionals and remote patients [50,51].

A study investigated the possibility of carrying out the spirometric test directly at home in total autonomy. The study involved four patients with previous chronic obstructive bronchopathy who were provided with telespirometry equipment equipped with tablets capable of supporting the patient in the examination. This system was used for 12 weeks in which patients performed several daily spirometries without any medical assistance. As a result, the large part of the spirometry (94.5%) was considered acceptable and usable by qualified personnel [52]. Another study investigated the possibility of self-administration of the spirometric examination in asthmatic patients [53]. The author equipped 86 asthmatic patients with a portable instrument for spirometric measurements at home without medical supervision, evaluating their acceptability according to the American Thoracic Society and European Respiratory Society (ATS/ERS) criteria. The author set the primary endpoint with the following criteria: correct use of the device three or more times within 7 days (±1 day) in one of the 3 weeks of the study. Of 78 patients, 67 (86%) reached the primary endpoint. Seventy-five (96%) participants used the device correctly one or more times, and 10 (13%) patients managed to use the tool every day during the 3 weeks. The authors showed that remote self-assessment using spirometry equipment is a feasible practice [53].

Adequate training in performing the spirometric examination of technicians or operators onboard the vessel capable of ensuring high-quality standards in spirometry could be fundamental to generate reliable results that the occupational physician could then assess from another clinic suitable for the examination, obviously using portable technological spirometers. The quality of spirometry tests strongly depends on adherence to international recommendations [53,54]. There are different tools today, such as those that use Android micro-control technology to measure lung function. For example, this latest technology has reported excellent results on patients who have been analyzed both with an examination performed with the traditional spirometer and with the new micro-control technology providing very similar final values, with an accuracy of high measurement and for forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) indicating that this device, for example, could be usefully used in telemedicine and health surveillance. Furthermore, there is a remote assistance technology that uses a simple spirometer with a Bluetooth module, an ES application based on MATLAB, and a mobile app based on Android. In this case, the portable spirometer used in this study can be connected to a mobile phone via Bluetooth. This technology has been used to evaluate the chronic course of diseases such as COPD and asthma. During 6 months, 780 patients were assessed and diagnosed with an accuracy of 97.32% [55].

3.3. Blood Glucose Monitoring

Telemedicine interventions for diabetes can vary from simple reminder systems via text messages over complex web interfaces. Patients can upload their glucose levels measured with a home meter and other relevant data such as medications, eating habits, level of activity, and anamnesis. The measurement of blood glucose concentration represents an essential step in the management of diabetic disease—glycemic self-monitoring, in fact, is widely used by patients with type 1 and type 2 diabetes to verify metabolic compensation, to identify and treat episodes of hyper- and hypoglycemia and to adapt the hypoglycemic therapy to the conditions of life (nutrition, physical activity, stress, intercurrent diseases) [56]. In the field of diabetes, telemedicine is used in its various forms: remote glycemic monitoring, teleconsultation, personal medical records, telenursing, and call centers. Several studies have shown that real-time transmission of blood glucose data is achievable with evidence demonstrating improvements in terms of glycemic control [57].

3.4. Urine Analysis

Urinalysis is an important diagnostic screening test useful for diagnosing and monitoring nephrological and urological conditions. This test is also often used in general preventive screening [58]. Information technology has significantly reduced the analysis times following the collection of urine and often performed in specialized laboratories. Nowadays, many portable electronic readers are available that can analyze in real-time the urine collected on particular test strips [59]. To be effective, these devices must be economical, portable, precise, reliable, robust, powered by batteries, and usable by non-medical personnel as well [59].

A recent development consists of the use of smartphones to read and interpret the results of the test strips where urine is collected [60]. These smartphones are often combined with electronic pocket readers and reagent strips [61]. Dae-Sik Lee proposed in 2011 a mobile health platform by combining a pocket colorimetric reader with a smartphone and paper strips for urinalysis capable of analyzing glucose, proteins, bilirubin, ketones, nitrites, pH, specific gravity, erythrocytes, and leukocytes. Various tests carried out show that the device is efficient, inexpensive, and accurate [62]. The urine test strip is a device made up of strips on different distinct reactive zones allowing for the determination of specific gravity, pH, proteins, glucose, ketones, bilirubin, blood, nitrites, urobilinogen, and leukocytes in the urine. Often, the results have to be interpreted, and, in order to avoid human error, some digital scanners are able to interpret the results independently via the smartphone camera [63,64].

4. Legal Implications of Telemedicine

Telemedicine has significant repercussions in the delicate ethical sphere, as this different way of managing the interaction and communication between the patient and the doctor (or in general, the health workers involved) impacts a particular situation for who is in need of health care. On the other hand, on establishing the patient–doctor relationship, the safeguard of the dignity of the patient should be always safeguarded.

The legal problems related to telemedicine have not yet found standard solutions at the international level. Any request for telemedicine is considered a medical act. Hence, although many teleconsultation procedures are unique, the traditional principles of traditional doctor–patient relationships are also valid in telemedicine. Three concerns can be involved in legal performance issues [65,66]. As a result, in terms of the person who transmits the data, "informed consent must govern the relationship between the patient and other interested parties." This should include the patient's awareness of the technical aspects; the potential risks; the precautions required; and, at the same time, and the guarantee of the confidentiality of information [66]. The person who receives the data is the medical service user. Regarding the service provider, confidentiality, as well as the quality of the transmitted and received data, must be guaranteed by the service provider [66].

5. Recommendations

Telemedicine can be used successfully for pre-employment medical examinations and follow-up visits on board ships. This study used a narrative review to evaluate the possibility of telemedicine for periodically pre-employment medical exams and follow-up visits for workers needing to be followed aboard ships. We considered four major medical exams/tests for telemedicine applications in this review, namely, electrocardiogram (ECG), spirometry test, blood glucose monitoring, and urinalysis. As a result of telemedicine, we proposed the necessary medical examinations/tests with screening intervals to be included in the pre-employment medical examination (PEME) protocols (see Table 2). Table 2 summarizes features, medical tests, suggested periodicity, telemedicine modality, and equipment to be used for telemedicine practice in occupational medicine. Possible applications of telemedicine in the PEME, follow-up, and future visits are detailed below:

1. PEME: ECG, spirometry, measurement of vital signs (blood pressure, heart rate, and temperature), oxygen saturation assessed by a pulse oximeter, blood glucose measurement by glucometer, and urinalysis are tests that can be monitored remotely in some cases even without medical assistance. These tests are currently used for the general population in different medical specialties. We thus suggest using them both

for PEME visits and/or for periodic checks of seafarers aboard ships, provided that on board there is the necessary technological resource training.
2. Follow-up visits: Telemedical Maritime Assistance Services (TMAS) doctors can make multiple medical visits a single patient, guaranteeing appropriate evaluation standards. They can also follow the same patient for the necessary time by monitoring over time without the need for large displacements and without the need to visit inside the ships in person. The technological equipment should provide a secure and high-speed internet connection; a clinical telemedicine software that acts as a hub capable of sending the patient's vital parameters to the doctor; devices capable of monitoring the patient's body parameters; and, finally, an ad hoc training program with periodic simulations. If fitted onboard, these systems could also help a TMAS doctor make a correct diagnosis and plan adequate treatment.
3. Future activities: the possibility of carrying out preventive medicine tests using telemedicine technologies could be considered in the future as a fundamental element for remote maritime preventive medicine practice. Specific experimental studies of devices integrated into platforms, protocols, and patient satisfaction should be conducted, possibly using targeted comparisons with traditional systems.

Table 2. The proposed general medical examinations and tests for seafarers on board ships using telemedicine technologies.

Features	Medical Examination	Periodicity	Telemedicine Modality	Equipment
General well-being	Medical history	Annual basis	Video, e-mail	Telemedicine devices
Noise	Audiometry test	Annual basis	Audio, video	Telemedical devices
General well-being Stress-related	Electrocardiogram (ECG), spirometry, urinalysis	Every six months	Still image Video	Telemedical devices
Vibrations	Postural evaluation: manual handling of loads	Annual basis	Video	Telemedicine devices
Exposure to toxic substances	Blood chemistry tests aimed at checking cardiovascular and renal function (blood count, blood sugar, liver and kidney function, lipid structure); leukocyte formula, urinalysis, determination of urinary hydroxypyrene.	Annual basis	E-mail, audio, video	Telemedicine devices
	Pulse oximetry, blood pressure	Every month	Video, e-mail	Telemedical devices
Postural workload	Body mass index evaluation; postural evaluation	Annual basis	Video	Telemedical devices
Fatigue and stress assessment	Electrocardiogram and saturimetry for fatigue; stress assessment, see the appropriate section of this protocol	Annual basis	Video, e-mail	Telemedical devices

6. Conclusions

This narrative review has highlighted how telemedicine and devices for the detection of body parameters in the medical field are extensively practiced in many specialties of modern medicine. This review evaluated telemedicine's feasibility for pre-employment medical examinations (PEMEs) and follow-up visits aboard ships. It recommended the necessary medical examinations/tests such as ECG, spirometry test, blood glucose monitoring, and urinalysis with screening intervals for seafarers' onboard ships be considered in the PEME protocol. Moreover, recommendations were provided to responsible bodies, stakeholders, and researchers to implement telemedicine during the PEME and study its effectiveness. However, in many countries around the world, telemedicine is not an integral part of the health system, and thus it is legitimate to assume that the full potential of telemedicine has not yet been exploited. This review shows that with the advent of new technologies such as high-speed internet, video conferencing, and digital examinations, it is possible to report the necessary tests and perform virtual medical exams on board vessels. Telemedicine can be a fundamental element for the prevention and treatment required in health surveillance, particularly for the conditions in which reaching the patient is difficult and expensive, such as onboard ships.

Author Contributions: G.G.S.: conception and design the study, acquisition of data, analysis and interpretation of results, and drafting the manuscript. M.D.C.: acquisition and interpretation of data. E.T.: designing the study, drafting the initial manuscript, and acquisition of data. F.A.: revising the manuscript critically for important intellectual content and reviewing the study. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable for studies not involving humans or animals.

Informed Consent Statement: Not applicable for studies not involving humans.

Data Availability Statement: Data sharing not applicable.

Conflicts of Interest: The authors declare that no conflict of interest.

References

1. *A Health Telematics Policy in Support of WHO's Health-for-All Strategy for Global Health Development*; Report of the WHO Group Consultation on Health Telematics; World Health Organization: Geneva, Switzerland, 1997; pp. 11–16.
2. Sagaro, G.G.; Amenta, F. Past, present, and future perspectives of telemedical assistance at sea: A systematic review. *Int. Marit. Health* **2020**, *71*, 97–104. [CrossRef]
3. Craig, J.; Patterson, V. Introduction to the practice of telemedicine. *J. Telemed. Telecare* **2005**, *11*, 3–9. [CrossRef] [PubMed]
4. *Telemedicine: Opportunities and Developments in Member States*; Report on the Second Global Survey on EHealth; World Health Organization: Geneva, Switzerland, 2009.
5. Combi, C.; Pozzani, G.; Pozzi, G. Telemedicine for Developing Countries. *Appl. Clin. Inform.* **2016**, *7*, 1025–1050. [CrossRef]
6. International Labour Organisation. Medical Advice at Sea Recommendation, 1958 (No. 106). Available online: https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:R106 (accessed on 20 July 2020).
7. Bloor, M.; Thomas, M.; Lane, T. Health risks in the global shipping industry: An overview. *Health Risk Soc.* **2000**, *2*, 329–340. [CrossRef]
8. Oldenburg, M.; Baur, X.; Schlaich, C. Occupational Risks and Challenges of Seafaring. *J. Occup. Health* **2010**, *52*, 249–256. [CrossRef] [PubMed]
9. Hemmingsson, T.; Lundberg, I.; Nilsson, R.; Allebeck, P. Health-related selection to seafaring occupations and its effects on morbidity and mortality. *Am. J. Ind. Med.* **1997**, *31*, 662–668. [CrossRef]
10. Nittari, G.; Tomassoni, D.; Di Canio, M.; Traini, E.; Pirillo, I.; Minciacchi, A.; Amenta, F. Overweight among seafarers working on board merchant ships. *BMC Public Health* **2019**, *19*. [CrossRef]
11. Jaremin, B.; Kotulak, E.; Starnawska, M.; Tomaszunas, S. Causes and Circumstances of Deaths of Polish Seafarers During Sea Voyages. *J. Travel Med.* **1996**, *3*, 91–95. [CrossRef]
12. Yılmaz, F. Marine Mi-Gjosa. An Analysis of Marine Casualties of Turkish Flagged Ships and Effects on Sea-Men. Available online: http://www.gmoshipmar.org/jvi.aspx?pdir=gmo&plng=eng&un=GMO-99608&look4= (accessed on 20 July 2020).
13. Lalić, H. Occupational medicine professor's participation in erasmus+: Academic staff exchange programme. *Coll Antropol.* **2017**, *41*, 305–308.
14. Williams, A.M.; Bhatti, U.F.; Alam, H.B.; Nikolian, V.C. The role of telemedicine in postoperative care. *mHealth* **2018**, 1–9. [CrossRef]
15. Adler-Milstein, J.; Kvedar, J.; Bates, D.W. Telehealth Among US Hospitals: Several Factors, Including State Reimbursement and Licensure Policies, Influence Adoption. *Health Aff.* **2014**, *33*, 207–215. [CrossRef]
16. Withnall, R.D.J.; Smith, M.; Graham, D.J.; Morris, L.E. Telemedicine in the UK Defence Medical Services: Time for an upgrade? *J. R. Army Med. Corps* **2016**, 207–215. [CrossRef] [PubMed]
17. Wilson, L.S.; Maeder, A. Recent Directions in Telemedicine: Review of Trends in Research and Practice. *Health Inform. Res.* **2015**, *21*, 213–222. [CrossRef] [PubMed]
18. Mph, H.S.S.; Hamline, M.Y.; Gosdin, M.M.; Kair, L.R.; Weinberg, G.M.; Marcin, J.P.; Rosenthal, J.L. Acceptability, Usability, and Effectiveness: A Qualitative Study Evaluating a Pediatric Telemedicine Program. *Acad. Emerg. Med.* **2019**, *26*, 1022–1033. [CrossRef]

19. Srinivasan, R.; Ben-Pazi, H.; Dekker, M.; Cubo, E.; Bloem, B. Telemedicine for Hyperkinetic Movement Disorders. Tremor and Other Hyperkinetic Movements. *Tremor. Other. Hyperkinetic. Mov.* **2020**, 1–8. [CrossRef]
20. Demaerschalk, B.M.; Berg, J.; Chong, B.W.; Gross, H.; Nystrom, K.; Adeoye, O.; Schwamm, L.; Wechsler, L.; Whitchurch, S. American Telemedicine Association: Telestroke Guidelines. *Telemed. eHealth* **2017**, 376–389. [CrossRef]
21. Hazenberg, C.E.V.B.; De Stegge, W.B.A.; Van Baal, S.G.; Moll, F.L.; Bus, S.A. Telehealth and telemedicine applications for the diabetic foot: A systematic review. *Diabetes Metab. Res. Rev.* **2020**, e3247. [CrossRef] [PubMed]
22. Bashshur, R.L.; Shannon, G.W.; Bashshur, N.; Yellowlees, P.M. The Empirical Evidence for Telemedicine Interventions in Mental Disorders. *Telemed. eHealth* **2016**, *22*, 87–113. [CrossRef] [PubMed]
23. Endler, M.; Lavelanet, A.; Cleeve, A.; Ganatra, B.; Gomperts, R.; Gemzell-Danielsson, K. Telemedicine for medical abortion: A systematic review. *BJOG Int. J. Obstet. Gynaecol.* **2019**, *126*, 1094–1102. [CrossRef] [PubMed]
24. Abel, E.A.; Shimada, S.L.; Wang, K.; Ramsey, C.; Skanderson, M.; Erdos, J.; Godleski, L.; Houston, T.K.; Brandt, C.A.; Whealin, J.; et al. Dual Use of a Patient Portal and Clinical Video Telehealth by Veterans with Mental Health Diagnoses: Retrospective, Cross-Sectional Analysis. *J. Med. Internet Res.* **2018**, *20*. [CrossRef] [PubMed]
25. Spencer, T.; Noyes, E.; Biederman, J. Telemedicine in the Management of ADHD: Literature Review of Telemedicine in ADHD. *J. Atten. Disord.* **2019**, *24*, 3–9. [CrossRef]
26. International Labour Organisation. Guidelines on the Medical Examinations of Seafarers Sectoral Activities Pro-gramme. Available online: www.ilo.org/publns (accessed on 23 December 2020).
27. Legislative Decree n. 81. Available online: https://www.gazzettaufficiale.it/eli/id/2008/04/30/008G0104/sg (accessed on 20 July 2020).
28. Legislative Decree n. 271. Available online: https://www.gazzettaufficiale.it/eli/id/1999/08/09/099G0350/sg (accessed on 20 July 2020).
29. Legislative Decree n. 626. Available online: https://www.gazzettaufficiale.it/eli/id/1994/11/12/094G0610/sg (accessed on 20 July 2020).
30. De Rosa, C.; Di Mizio, G.; Ricci, P. Accidents and occupational diseases in seafarers: Role of health surveillance. *Soc Def.* **2005**, *84*, 129–136.
31. Mahdi, S.S.; Amenta, F. Eighty years of CIRM. A journey of commitment and dedication in providing maritime medical assistance. *Int. Marit. Health* **2016**, *67*, 187–195. [CrossRef] [PubMed]
32. Iannitti, T.; Di Cerbo, A.; Morales-Medina, J.C.; Palmieri, B. Narrative review of telemedicine consultation in medical practice. *Patient Prefer. Adherence* **2015**, *9*, 65–75. [CrossRef] [PubMed]
33. Molinari, G.; Molinari, M.; Di Biase, M.; Brunetti, N.D. Telecardiology and its settings of application: An update. *J. Telemed. Telecare* **2017**, *24*, 373–381. [CrossRef]
34. Inglis, S.C.; Clark, R.A.; McAlister, F.A.; Ball, J.; LeWinter, C.; Cullington, D.; Stewart, S.; Cleland, J.G. Structured telephone support or telemonitoring programmes for patients with chronic heart failure. *Cochrane Database Syst. Rev.* **2010**. [CrossRef]
35. Lin, C.-T.; Chang, K.-C.; Lin, C.-L.; Chiang, C.-C.; Lu, S.-W.; Chang, S.-S.; Lin, B.-S.; Liang, H.-Y.; Chen, R.-J.; Lee, Y.-T.; et al. An Intelligent Telecardiology System Using a Wearable and Wireless ECG to Detect Atrial Fibrillation. *IEEE Trans. Inf. Technol. Biomed.* **2010**, *14*, 726–733. [CrossRef] [PubMed]
36. Ong, M.K.; Romano, P.S.; Edgington, S.; Aronow, H.U.; Auerbach, A.D.; Black, J.T.; De Marco, T.; Escarce, J.J.; Evangelista, L.S.; Hanna, B.; et al. Effectiveness of Remote Patient Monitoring After Discharge of Hospitalized Patients with Heart Failure: The Better Effectiveness After Transition–Heart Failure (BEAT-HF) Randomized Clinical Trial. *JAMA Intern. Med.* **2016**, *176*, 310–318. [CrossRef]
37. Chaudhry, S.I.; Mattera, J.A.; Curtis, J.P.; Spertus, J.A.; Herrin, J.; Lin, Z.; Phillips, C.O.; Hodshon, B.V.; Cooper, L.S.; Krumholz, H.M. Telemonitoring in Patients with Heart Failure. *N. Engl. J. Med.* **2010**, *363*, 2301–2309. [CrossRef]
38. Majumder, S.; Mondal, T.K.; Deen, M.J. Wearable Sensors for Remote Health Monitoring. *Sensors* **2017**, *17*, 130. [CrossRef] [PubMed]
39. Sohn, S.; Helms, T.M.; Pelleter, J.T.; Müller, A.; Kröttinger, A.I.; Schöffski, O. Costs and Benefits of Personalized Healthcare for Patients with Chronic Heart Failure in the Care and Education Program "Telemedicine for the Heart". *Telemed. eHealth* **2012**, *18*, 198–204. [CrossRef] [PubMed]
40. De Lazzari, C.; Pisanelli, D.M.; D'Ambrosi, A.; Genuini, I.; Fedele, F. Telecardiology in Italy: Current realizations and future prospects. *Front Artif. Intell. Appl.* **2011**, *231*, 315–330. [CrossRef]
41. De Lazzari, C.; Genuini, I.; Gatto, M.C.; Cinque, A.; Mancone, M.; D'Ambrosi, A.; Silvetti, E.; Fusto, A.; Pisanelli, D.M.; Fedele, F. Screening high school students in Italy for sudden cardiac death prevention by using a telecardiology device: A retrospective observational study. *Cardiol. Young* **2016**, *27*, 74–81. [CrossRef] [PubMed]
42. Lupi, L.; Glisenti, F.; Papa, I.; Arabia, G.; Piazzani, M.; Fabbricatore, D.; Castiello, A.; Madureri, A.; Nodari, S. P4234A telemonitoring program for screening and primary and secondary prevention of cardiovascular disease. *Eur. Heart J.* **2018**, *39*, 860. [CrossRef]
43. Yeong, K.S.; Kang, D.M.; Kim, J.I. 802 Spirometry longitudinal data analysis software (spirola) for respiratory disease prevention among shipyard welders in South Korea. *Respir. Disord.* **2018**, *91*, A460.
44. Wheatley, J. Spirometry: Key to the diagnosis of respiratory disorders. *Med. J. Aust.* **2017**, *207*, 422–424. [CrossRef] [PubMed]

45. Molina-Bastos, C.G.; Gadenz, S.D.; Angela, M.; Moreira, F. Telespirometry in primary health care: A randomized clinical trial in southern Brazil (research protocol). *J. Bras. Telessaúde Rio Jan.* **2016**, *4*, 82–83.
46. Averame, G.; Bonavia, M.; Ferri, P.; Moretti, A.M.; Fogliani, V.; Cricelli, C.; Canonica, G.W.; Grassi, C.; Paggiaro, P.L.; Rossi, A. Office spirometry can improve the diagnosis of obstructive airway disease in primary care setting. *Respir. Med.* **2009**, *103*, 866–872. [CrossRef]
47. De Toledo, P.; Jimenez, S.; Del Pozo, F. A telemedicine system to support a new model for care of chronically ill patients. *J. Telemed. Telecare* **2002**, *8*, 17–19. [CrossRef]
48. Alrajab, S.; Smith, T.; Owens, M.; Areno, J.P.; Caldito, G. A Home Telemonitoring Program Reduced Exacerbation and Healthcare Utilization Rates in COPD Patients with Frequent Exacerbations. *Telemed. eHealth* **2012**, *18*, 772–776. [CrossRef]
49. Jouneau, S.; Dres, M.; Guerder, A.; Bele, N.; Bellocq, A.; Bernady, A.; Berne, G.; Bourdin, A.; Brinchault, G.; Burgel, P.R.; et al. Management of acute exacerbations of chronic obstructive pulmonary disease (COPD). Guidelines from the Société de pneumologie de langue française (summary). *Rev. Mal. Respir.* **2017**, *34*, 282–322. [CrossRef] [PubMed]
50. Vitacca, M.; Rossin, M.; Assoni, G.; Baratti, D.; Zanardini, M.; Ruocco, G.; Quinto, T.; Bernasconi, A.; Scalvini, S.; Colombo, F. Tele-assistance Respiratory Card: Feasibility of Self-Reporting in Patients with Severe COPD. *Telemed. eHealth* **2013**, *19*, 99–103. [CrossRef]
51. Ohberg, F.; Wadell, K.; Blomberg, A.; Claesson, K.; Edstrom, U. Home-Based System for Recording Pulmonary Function and Disease-Related Symptoms in Patients with Chronic Obstructive Pulmonary Disease, COPD-A Pilot Study. *SM J. Pulm. Med.* **2016**, *2*, 1011.
52. Kupczyk, M.; Hofman, A.; Kołtowski, Ł.; Kuna, P.; Łukaszyk, M.; Buczyłko, K.; Bodzenta-Łukaszyk, A.; Nastałek, P.; Soliński, M.; Dąbrowiecki, P. Home self-monitoring in patients with asthma using a mobile spirometry system. *J. Asthma* **2020**, 1–7. [CrossRef] [PubMed]
53. Redlich, C.A.; Tarlo, S.M.; Hankinson, J.L.; Townsend, M.C.; Eschenbacher, W.L.; Von Essen, S.G.; Sigsgaard, T.; Weissman, D.N. Official American Thoracic Society Technical Standards: Spirometry in the Occupational Setting. *Am. J. Respir. Crit. Care Med.* **2014**, *189*, 983–993. [CrossRef]
54. Stout, J.W.; Smith, K.; Zhou, C.; Solomon, C.; Dozor, A.J.; Garrison, M.M.; Mangione-Smith, R. Learning from a Distance: Effectiveness of Online Spirometry Training in Improving Asthma Care. *Acad. Pediatr.* **2012**, *12*, 88–95. [CrossRef] [PubMed]
55. Fung, A.G.; Tan, L.; Duong, T.N.; Schivo, M.; Littlefield, L.; Delplanque, J.-P.; Davis, C.E.; Kenyon, N.J.; Fung, T. Design and Benchmark Testing for Open Architecture Reconfigurable Mobile Spirometer and Exhaled Breath Monitor with GPS and Data Telemetry. *Diagnostics* **2019**, *9*, 100. [CrossRef]
56. Bruttomesso, D.; Laviola, L.; Avogaro, A.; Bonora, E.; Del Prato, S.; Frontoni, S.; Orsi, E.; Rabbone, I.; Sesti, G.; Purrello, F. The use of real time continuous glucose monitoring or flash glucose monitoring in the management of diabetes: A consensus view of Italian diabetes experts using the Delphi method. *Nutr. Metab. Cardiovasc. Dis.* **2019**, *29*, 421–431. [CrossRef] [PubMed]
57. Rodriguez-Gutierrez, R.; Gonzalez-Gonzalez, J.G.; Zuñiga-Hernandez, J.A.; McCoy, R.G. Benefits and harms of intensive glycemic control in patients with type 2 diabetes. *BMJ* **2019**, *367*, l5887. [CrossRef]
58. Hannemann-Pohl, K.; Kampf, S.C. Automation of Urine Sediment Examination: A Comparison of the Sysmex UF-100 Automated Flow Cytometer with Routine Manual Diagnosis (Microscopy, Test Strips, and Bacterial Culture). *Clin. Chem. Lab. Med.* **1999**, *37*, 753–764. [CrossRef]
59. Langlois, M.R.; Delanghe, J.R.; Steyaert, S.R.; Everaert, K.C.; De Buyzere, M.L. Automated Flow Cytometry Compared with an Automated Dipstick Reader for Urinalysis. *Clin. Chem.* **1999**, *45*, 118–122. [CrossRef]
60. Mohammadi, S.; Maeki, M.; Mohamadi, R.M.; Ishida, A.; Tani, H.; Tokeshi, M. An instrument-free, screen-printed paper microfluidic device that enables bio and chemical sensing. *Analyst* **2015**, *140*, 6493–6499. [CrossRef]
61. Ginardi, R.V.H.; Saikhu, A.; Sarno, R.; Sunaryono, D.; Kholimi, A.S.; Shanty, R.N.T. Intelligent Method for Dipstick Urinalysis Using Smartphone Camera. In *Lecture Notes in Computer Science*; Springer: Berlin, Germany, 2014; Volume 8407, pp. 66–77.
62. Lee, D.-S.; Jeon, B.G.; Ihm, C.; Park, J.-K.; Jung, M.Y. A simple and smart telemedicine device for developing regions: A pocket-sized colorimetric reader. *Lab Chip* **2011**, *11*, 120–126. [CrossRef]
63. Soldat, D.J.; Barak, P.; Lepore, B.J. Microscale Colorimetric Analysis Using a Desktop Scanner and Automated Digital Image Analysis. *J. Chem. Educ.* **2009**, *86*, 617–620. [CrossRef]
64. Montangero, M. Determining the Amount of Copper(II) Ions in a Solution Using a Smartphone. *J. Chem. Educ.* **2015**, *92*, 1759–1762. [CrossRef]
65. Nittari, G.; Khuman, R.; Baldoni, S.; Pallotta, G.; Battineni, G.; Sirignano, A.; Amenta, F.; Ricci, G. Telemedicine Practice: Review of the Current Ethical and Legal Challenges. *Telemed. J. E Health* **2020**, *26*, 1427–1437. [CrossRef]
66. Pirillo, I.; Amenta, F.; Sirignano, A.; Ricci, G. Cross-border healthcare: Implementation of Directive 2011/24/EU and National Contact Point in Italy. *Travel. Med. Infect. Dis.* **2017**, *18*, 79–80. [CrossRef]

Journal of Taibah University Medical Sciences (2021) 16(3), 305–306

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Editorial Article

Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic?

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Received 22 December 2020; revised 15 February 2021; accepted 17 February 2021; Available online 18 March 2021

Dear Editor,

On 9 January 2020, China's Centres for Disease Control and Prevention (CDC) reported that a novel coronavirus causing a severe acute respiratory syndrome (SARS-CoV-2) had been identified as the causative agent of an aggressive respiratory disease, later referred to as coronavirus disease 2019 (COVID-19).[1] As of 18 January 2021, there have been over 90 million reported cases of COVID-19 and the virus has been responsible for nearly 2.5 million deaths.[2] The COVID-19 emergency has required continued contingency plans, making it necessary to both rethink the current approach to healthcare as well as how to adapt to the emerging needs of healthcare in the context of a pandemic. We have learned how to mitigate the spread of the virus by implementing social distancing measures, enforcing proper mask compliance, and reducing face-to-face contact in a health setting unless absolutely necessary. Community spread from the virus must be prevented to minimise the risks of infection for health professionals. In this respect, essential telemedicine services may help safeguard public health in significant ways.[3]

The term 'telemedicine' was introduced in the 1970s by Thomas Bird, an American who used it to refer to the delivery of medical assistance via telecommunication devices without a physical meeting between doctors and patients.[4] In simple words, telemedicine can be defined as the provision of healthcare for people in remote areas when the providers and receivers of assistance are not in the same place. There is a substantial body of scientific literature that specifically discusses the potential of telemedicine. Notably, telemedicine encompasses the use of video consultations, electronic prescriptions, and remote management and monitoring of symptoms and vital parameters. This can become an indispensable response, especially in disasters like COVID-19 and other high-risk situations involving public health.

No telemedicine programme can be created and activated overnight; however, the health systems of countries like the United States, United Kingdom, Germany, and Canada have already invested in telemedicine, thereby ensuring that COVID-19 patients will receive the treatment and assistance they need.[5] In Italy, the use of telemedicine in the pandemic context has become a topic of interest, as evidenced by the documents provided by the National Institute of Health (NIH) (Istituto Superiore di Sanità, ISS).[6] There have been national guidelines on the use of telemedicine since 2012, but there are still several obstacles to implementation such as service costs and the lack of regulations.[7] This hinders the effective use of these tools throughout the national territory. All activities involving a citizen's personal and health data, which are essential for the provision of telemedicine services, are subject to the secure processing of sensitive data carried out through electronic tools. Thus, the fundamental methods and solutions have to ensure data confidentiality, integrity and availability; therefore, in any case, telemedicine has to be adopted as per the government rules.

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Peer review under responsibility of Taibah University.

ELSEVIER Production and hosting by Elsevier

1658-3612 https://doi.org/10.1016/j.jtumed.2021.02.009

It is important to ensure the responsible use of telemedicine systems, and this can only be possible when the systems are used with better care and in the interest of public safety. The implementation of telemedicine should focus on monitoring patients with mild or asymptomatic cases, which then reduces hospital overcrowding. Accordingly, the possibility that crowding will be lessened also reduces virus spread, not only for patients but also for healthcare personnel.[8] The usefulness of telemedicine solutions during the COVID-19 pandemic has already been confirmed in the case of remote areas in China, where the mortality rates and the virus spread were significantly higher than in cities with good healthcare systems.

New pandemic events created unique challenges in the provision of healthcare services. Although telemedicine does not present a solution to all problems, it is an important healthcare resource for people who are highly stressed. This includes citizens living in areas where medical services are difficult to access for geographic or other reasons, along with seafarers, who, when at sea, are essentially remote individuals.[9] The provision of telemedicine should also comply with the ethical and legal standards attached to the medical profession, although relevant gaps still exist between the potentialities of technology and legislation/regulations.[10] In terms of user responsibilities, it is important to highlight ethical issues concerning telemedicine.

With good reason, the current COVID-19 emergency is a call to action. The political responses of governments should include clear provisions on different fronts to evaluate their telemedicine measures as well as their interconnected implications. Subsequently, after the emergency phase, it will also be important to determine if these new approaches can help establish best practices in medicine that respect both the patients and organisations. Once telemedicine has been introduced to the Italian environment, if it is uniformly well-regulated throughout the national territory, it can play a significant role in responding to the current pandemic as well as any future such crises. Telemedicine also presents a solution to the anticipated future lack of healthcare personnel and to the vulnerability of the National Health Service (NHS) as exposed by the COVID-19 pandemic. It will then become necessary to think about and outline specific catalytic experiences—which are understood as contexts of dialogue and discussion, of education and learning as well as of regulations— to try to transform the challenges posed by the emergency into opportunities for improvement.

Telemedicine has consistently become more important over the past few decades; the COVID-19 new pandemic has only underscored the importance of its immediate adoption. Furthermore, reports indicate that between February 2020 to June 2020, telemedicine consultations sharply increased from 36 million to 200 millionand are soon projected to reach 1 billion by end of 2020.[11] With telemedicine's present direction and widespread adoption, it can disrupt current well-being frameworks, as well as manage costs and care delivery, thus creating a stage for vastly unique medical services in the future.

Source of funding

This work was supported in part by the ITF Trust (London, UK) grant No. 1508/2020.

Conflict of interest

The authors have no conflict of interest to declare

Ethical approval

The authors confirm that this editorial had been prepared in accordance with COPE roles and regulations. Given the nature of the editorial, the IRB review was not required.

Authors' contributions

GB and GN conducted research, provided research materials, and collected and organised data. GB, AS and FA wrote the initial and final draft of the article. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

References

1. Sharma AK. Novel coronavirus disease (COVID-19). **Resonance 2020**; 25(5): 647–668.
2. Home - Johns Hopkins Coronavirus Resource Center. *Toegang verkry*; January 18, 2021 https://coronavirus.jhu.edu/.
3. Bashshur R, Doarn CR, Frenk JM, Kvedar JC, Woolliscroft JO. Telemedicine and the COVID-19 pandemic, lessons for the future. **Telemed e-Health. 2020**; 26(5): 571–573.
4. Strehle EM, Shabde N. One hundred years of telemedicine: does this new technology have a place in paediatrics? **Arch Dis Child 2006**; 91(12): 956–959.
5. Hollander JE, Carr BG. Virtually perfect? Telemedicine for covid-19. **N Engl J Med 2020**; 382(18): 1679–1681.
6. Piasecki J, Dranseika V. Research versus practice: the dilemmas of research ethics in the era of learning health-care systems. **Bioethics 2019**; 33(5): 617–624.
7. Interim indications for telemedicine assistance services during the COVID-19 health emergency | Order of psychologists Veneto. Toegang verkry December 11, 2020. https://www.ordinepsicologiveneto.it/ita/content/indicazioni-ad-interim-per-servizi-assistenziali-di-telemedicina-durante-l-emergenza-sanitaria-covid-19.
8. Stipa G, Gabbrielli F, Rabbito C, Di Lazzaro V, Amantini A, Grippo A, et al., Telemedicine Working Group. The Italian technical/administrative recommendations for telemedicine in clinical neurophysiology. **Neurol Sci 2020 Sep 24**: 1–9.
9. Mittal M, Battineni G, Goyal LM, Chhetri B, Oberoi SV, Chintalapudi N, et al. Cloud-based framework to mitigate the impact of COVID-19 on seafarers' mental health. **Int Marit Health 2020**; 71(3): 213–214.
10. Nittari G, Khuman R, Baldoni S, Pallotta G, Battineni G, Sirignano A, et al. Telemedicine practice: review of the current ethical and legal challenges. **Telemed J E Health 2020 Dec**; 26(12): 1427–1437.
11. Telehealth visits could top 1 billion in 2020 amid the coronavirus crisis. Toegang verkry Februarie 15, 2021. https://www.cnbc.com/2020/04/03/telehealth-visits-could-top-1-billion-in-2020-amid-the-coronavirus-crisis.html.

How to cite this article: Battineni G, Nittari G, Sirignano A, Amenta F. Are telemedicine systems effective healthcare solutions during the COVID-19 pandemic?. J Taibah Univ Med Sc 2021;16(3):305–306.

International Journal of Information Management Data Insights 1 (2021) 100005

Contents lists available at ScienceDirect

International Journal of Information Management Data Insights

journal homepage: www.elsevier.com/locate/jjimei

Text mining with sentiment analysis on seafarers' medical documents

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ARTICLE INFO

Keywords:
Text mining
Seafarers
Sentiment analysis
Word clouds
Machine learning

ABSTRACT

Digital health systems contain large amounts of patient records, doctor notes, and prescriptions in text format. This information summarized over the electronic clinical information will lead to an improved quality of healthcare, the possibility of fewer medical errors, and low costs. Besides, seafarers are more vulnerable to have accidents, and prone to health hazards because of work culture, climatic changes, and personal habits. Therefore, text mining implementation in seafarers' medical documents can generate better knowledge of medical issues that often happened onboard. Medical records are collected from digital health systems of Centro Internazionale Radio Medico (C.I.R.M.) which is an Italian Telemedical Maritime Assistance System (TMAS). Three years (2018–2020) patient data have been used for analysis. Adoption of both lexicon and Naïve Bayes' algorithms was done to perform sentimental analysis and experiments were conducted over R statistical tool. Visualization of symptomatic information was done through word clouds and 96% of the correlation between medical problems and diagnosis outcome has been achieved. We validate the sentiment analysis with more than 80% accuracy and precision.

1. Introduction

Sailing on ships is one of the risky occupations with its perks towards personal health and safety measures, and seafarers are highly vulnerable to have accidents and different diseases because of work culture, climatic changes, personal habits, etc. (Bal, Arslan & Tavacioglu, 2015; Nittari et al., 2019). On other side, seafarers may largely experience fatal and serious injuries. The main causes behind this are dangerous work practices, neglecting ship rules, and regulations (Çakir, 2019).

There could be possible differences in accident rates between merchant ships from different nationalities. It is proven by Ádám, Rasmussen, Pedersen and Jepsen (2014) work that specifies that western European seafarers (Danish) were had an overall injured rate of 17.5 per 100,000 person-days, and this is significantly higher than Eastern European, Southeast Asian, and Indian seaman. When a seafarer is ill or has an injury , the ship in charge contact the Telemedical Maritime Assistance Service (TMAS) center for immediate help (Westlund, Attvall, Nilsson & Jensen, 2016). These centers can be able to assist them through telemedicine , and patient records are carefully stored in digital health systems. In this study, we have collected seafarer medical documents from the Italian TMAS center called Centro Internazionale Radio Medico (C.I.R.M), which is offering medical assistance to seafarers for 85 years (Mahdi & Amenta, 2016).

The applications of text mining (TM) have continuously evolved in modern times. In the healthcare industry, there are several studies on artificial intelligence (AI) techniques including machine learning (ML), drug classification, and predictive analytics (Battineni, Sagaro, Chintalapudi & Amenta, 2020). However, because of medical database evolution, TM is getting high in demand to understand patient opinion on provided medical services (Friedman, Rindflesch & Corn, 2013). In the healthcare sector, text analytic operations are very often used to understand patient satisfaction and maintain streamlined operations (Kim & Delen, 2018).

Besides, opinion mining or sentiment analysis can be able to manage the interpretation of subjective statements and user responses (Rathore, Kar & Ilavarasan, 2017). In healthcare, sentiment analysis is popular because of its advantages during the assessment of medical records and makes it easy for doctors in decision making. When the patient got a sickness, the doctor diagnoses the patient's condition based on the symptomatic data and stores it in digital health systems called electronic health records (EHR).

In EHR, the doctor describes his opinion or observations that intends to understand patient feedback (Denecke & Deng, 2015). In such conditions, opinion mining helps to understand the patient attitude regarding to the principal contextual polarity of health records. This is true especially when doctors and patients express their opinion about health services and issues through online platforms like social media, blogs, and websites. Many studies (Khadjeh Nassirtoussi, Aghabozorgi, Wah & Ngo,

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https://doi.org/10.1016/j.jjimei.2020.100005
Received 30 October 2020; Received in revised form 9 December 2020; Accepted 10 December 2020

2014; Zhang, Chen & Liu, 2015) attempted to use opinion mining in different sectors like healthcare, business, banking, and others but there is no study in the maritime domain. In this work we have implemented sentiment analysis with TM to evaluate symptomatic information of seafarer's pathologies since life at sea makes it complicated in the absence of health professionals onboard.

In this paper, we randomly selected more than 3000 seafarer three years (2018–20) medical documents from C.I.R.M, and we have conducted experiments over three different corpora related to diagnostics of medical problems. Each corpus indicates the severity of an individual medical problem. We incorporated text mining methods in medical document analysis and a review of common pathologies that occurred onboard. In particular, the following research questions have been explored in this analysis.

RQ1: What are the frequent medical problems that occurred onboard?
RQ2: How text mining approaches are incorporated in the seafarer's health records?
RQ3: How seafarers' express problems associated with diseases?
RQ4: Is there any association between different symptom clusters knowledge extraction through health data mining?

The rest of the article was framed as follows. Section 2 provides the research background, including the main causes of health issues happening onboard. Section 3 covers the methods part including data extraction, interpretation, and experimental framework. Section 4 presents the interpretation of results and research outcomes. Section 5 provides a discussion on findings and existing literature. Finally, Section 6 provides study conclusions and the future scope of the present research.

2. Research background

Over the years, seafarers' health has to get great attention to international platforms, probably because of their significant contributions in world trades (Zhang en & Zhao, 2017). The international maritime organization (IMO) estimates that over 90% of global trade was done through ships (Zaman, Pazouki, Norman, Younessi & Coleman, 2017). Because of ship movements, there is a possibility of always having musculoskeletal strain, continuous noise, and vibration (Nittari et al., 2019). Despite this, being a seafarer getting injuries onboard is common as seafaring is a high-risk occupation when compared to others. As of this, onboard safety is one of the major concerns for both seafarers and ship owners.

Seafaring is the most hazardous occupation in terms of personal health and safety measures of seafarers. Since seafarers are exposed to continuous working hours on the sea, it makes them have different health problems. O Occupational injuries usually happen in small vessels, and may be often serious (Zytoon & Basahel, 2017). The special work challenges associated with the marine industry and ship activities were implied to risk involvement in accidents at work. These challenges might involve the behavioral safety of employees, workplace conditions, job type, onboard system management, and safety measures (Fabiano, Currò & Pastorino, 2004). Human conditions were playing an important role in the cause of occupational injuries. Moving from one-to-many places onboard can cause severe accidents, and the highest number of accidents was registered on deck.

When compared with onshore workers , factors such as rapid climate changes, a higher degree of air humidity, rain, wind, and intense solar radiation can cause mental and physical problems for seafarers (Wadsworth, Allen, Wellens, McNamara & Smith, 2006). Length in working hours, socio-psychological factors, and others may also influence the seafarers' health. Moreover, infectious and non-communicable disease burden and quality of services provided onboard may represent other problems in seafarers (Oldenburg, Baur & Schlaich, 2010).

Depression in sailors commonly associated their low mind-set with confinement from family, manager requests, inconvenience resting, and contract length (Mellbye & Carter, 2017). Decreasing seafarer's confinement from family is an inherently big challenge (though they had a video conferencing facility with family contacts), while other work elements might be limited with proper work-natural intercessions in a joint effort by ship owners.

Better social support and supervision while onboard are significant predictors of seafarers' mental health status rather than someone who had a history of mental disorder and poor education. At the same time, keeping physically active is also mandatory. For instance, providing guidance for suitable exercises or conducting sports activities on board could explore the release of happy hormones such as endorphin or serotonin (Battineni, Di Canio, Chintalapudi, Amenta and Nittari, 2019). Consequently, this will promote a sense of happiness and health. In the research of seafarers' happiness index, they addressed the direct connection between fitness and mental health (Kim & Jang, 2018). Therefore, it is always recommended to have an insight knowledge of factors that profoundly affect the behavioral and emotional well-being of seafarers.

On the other hand, prediction of patient emotion using TM methods completely depending on text data and could provide useful information based on EHR's of patients. Many studies highlighted the incorporation of TM on healthcare datasets. In Kukafka et al., authors developed a common language and framework for an International Classification of Functioning (ICF), health, and disability with advancing of TM techniques (Kukafka, Bales, Burkhardt & Friedman, 2006). It is also reported that with the application of natural language processing methods, it is easy to identify adverse trails related to central venous catheters (Penz, Wilcox & Hurdle, 2007). Similarly, Stusser and Dickey (2013) concluded TM and data mining in medical records can largely help to improve medical care and reduce costs. In this study, we aimed to recognize key pathologies that naturally occurred among sailors through TM approaches.

3. Methods

In this section, we summarize the random collection of medical documents from the C.I.R.M repository and an exploration of TM with sentiment techniques. The analysis was conducted by using R statistics 1.2.5 version including relevant packages like tm, ggplot2, and word cloud that are available on CRAN mirror. We collected seafarer's health documents from the C.I.R.M repository and preprocessed them for simulation purposes. Fig. 1 explains the experimental framework of TM with opinion mining approaches.

3.1. Experimental framework

The random selection of three-year patient documents was extracted. Each document contains textual information of the seafarer's medical problem and symptomatic data. We extracted 3112 documents available in the last three years (2018–2020). The documents are prepared in a CSV file format to ensure the importing of all the documents into the R platform.

3.2. Text preparation

Text preparation or preprocessing is a method, which transfers human text into a machine-readable format for further analysis. Text preprocessing contains many steps like text normalization, stemming, and tokenization.

3.2.1. Text normalization

In TM, it is necessary to conduct model training or algorithm with high amounts of data (Uysal & Gunal, 2014). For doing it, assembling frequent words into text corpus is commonly used in model benchmarking. This was done by the 'tm' package to do corpus building and is followed by removing of stop words (cleansing). Thereafter, we built term to document possibly as a special tokenizer. Each language has its

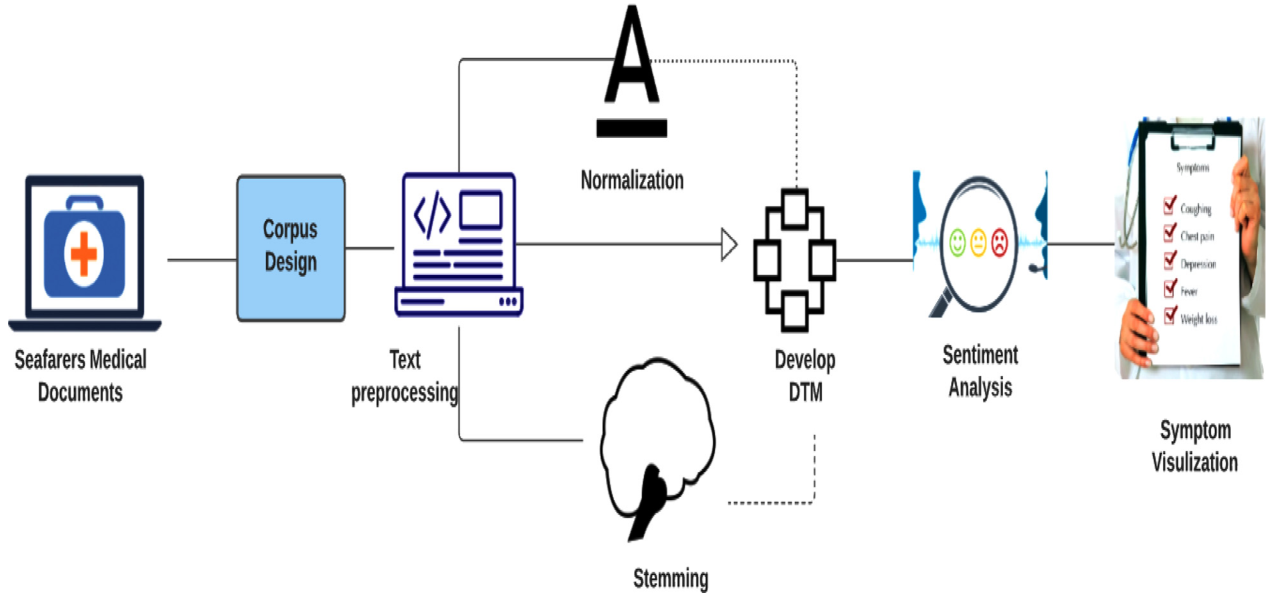

Fig. 1. An experimental framework.

Table 1
Sample medical abstracts in C.I.R.M repository.

Year	Case Number	Medical abstract
#2018	# 237	# Day 7/4, A Lituan Tankist, Slipping from The Ladder, While Going into The Deck, Falling With The Right Side Of The Thigh / Seat (Bringing A Significant Ecchymosis On That Side) And Rolling Was Throwing The Head Not In The Way Violent, Bringing Exercises On The Skin And A Small Ecchimosis In One Eye. He Did Not Report the Fact, Because, Other Than The Dams, He Feeled Well, In His Say. Yesterday, 8/4, I Received What Happened, Because I Had Headache And As Sensations Of Pressure / Pulsations. Mass Of Bags Of Ice Water. Some Heads Sometimes Slows Down And Sometimes And Stronger.
#2018	# 1352	# For Approximately A Week Has Present Abscess In The Inguinal Region Sin, Which Has Increased In Volume In The Last Days And Is Dolent To The Touch. Vital Parameters In The Standard.
#2019	#126	# Commander Informed That The Patient Disassembling From The Guard Shift Eaten A Sandwich Immediately Accusing After Acute Epigastric Pain. Patient Declares To Be The Carrier Of Iatale Hernia. A Buscopan Supposition Has Been Administered With Improvement Of Pain Symptomatology.
#2019	#2786	# A Favorable Opinion Is Required To Transfer Patient Sorentini Giulio, 58 Years, With Tracheo-Esophageal Fistula, From Crotone To Genoa, By Plane. The Patient Paz Would Be Accompanied By The Doctor.
#2019	#1985	# Captain Communicates Symptoms Of Maritime On Board, Lament Of Ocular Inflammation For More Than Twenty (20) Days. We Are Asked By A Medical Council
#2020	#36	# Gastro enteric Symptoms With Fever In Resolution After Drinking Water Not Certainly Drinkable
#2020	#101	# 29-Year Maritime Affected By About A Week Not Better Specified High Airway Infective Syndrome (Refer Cool), Dry Cough And Thermal Rise. 37.1 C
#2020	#1173	#30 Years Present Abdominal Skin Rash That Does Not Improve with Anti-Fungal Pomata. We Have No Images

individual corpus. In this study, collected patient records were available in the English language and further converted into data frames to build a corpus and mine similar symptom words. Table 1 presents sample patient comments that we received from the patient end. These medical abstracts or comments are aimed to diagnose patient problems but with full of noisy text, special characteristics, symbols, numbers, and buzzwords. All these were removed through normalization process.

3.2.2. Stemming

The follow-up to normalization, stemming is employed in cutting the beginning or end word by taking into account common prefixes and suffixes, which can be found in an inflected word (Kostoff, Toothman, Eberhart & Humenik, 2001). In this type of medical text, a number of inflected words, for example 'suffering', 'suffered' are identified through stemming and represent with the common word 'suffer'.

3.2.3. Tokenization

After normalization steps, a simple feature selection or symptom tokenization was done wit with the symptom words. Then, every single token can represent a symptom sparse matrix using the term frequency-inverse document frequency (t_f - id_f) described in Shafiei et al. (2007).

We consider corpus C with N medical documents (d_j) where j = 1,2, —, N-1, N, and symptoms tokenized as term t. The t_f - id_f-weighing scheme considers the relative importance of individual symptoms in the given documents and assigns to term (t_k) as a weight in document d_j defined in Eq. (1).

$$t_f - id_f\left(tk_{,}d_j\right) \;= t_f\left(t_{k,}d_j\right) * id_f\left(t_k\right) \quad (1)$$

Where t_f ($t_{k,}$ d_j) represents symptom frequency (i.e., the number of times symptom occurrence in medical documents), id_f (t_k) represents inverse medical document frequency, and d_f (t_k) presents the number of documents containing symptom.

3.3. Develop DTM or TDM

A document term matrix (DTM) is a mathematical matrix explaining the symptom frequency in medical records. In DTM, rows represent collected medical documents and columns correspond to terms (symptoms). In contrast, rows in the term-document matrix (TDM) represent terms (symptoms) and columns represent documents. Table 2 summarizes outcome of the TDM simulation.

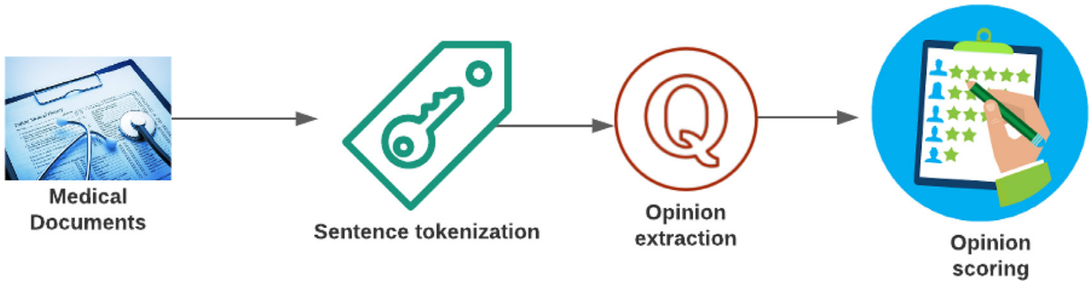

Fig. 2. The experimental approach of lexicon sentiment classification.

Table 2
TDM outcomes.

<<Term Document Matrix (terms: 2777, documents: 3112)>>	
Non-/sparse entries	1937/16,043
Sparsity	99%
Maximal term length	15
Weighting	term frequency (t_f)

Table 3
High associated symptom words correlated to diagnosis outcome.

Outcome diagnosis	Extracted terms (limit correlation 96%)			
Swelling	stiffness	Tenderness	redness	rash
Association	0.99	0.98	1	1
pain	swelling	Redskin	facture	bleeding
Association	1	0.99	1	1
abdominal	Swelling	Nausea	Fever	vomit
Association	1	1	0.96	0.98

3.4. Sentiment analysis

Sentiment classification, polarity measurement, and clustering of the entire corpus can be handled in this technique. We employed both lexicon and machine learning-based sentiment classification.

3.4.1. Lexicon sentiment classification

In this stage, it handles symptom classification and corpus clustering methods. We used the lexicon sentiment analysis (LSA) technique that defines individual terms search in the document and do weight calculation. LSA classifier is a sentiment scoring function that highlights all the symptoms in the corpus, no need for labeled data, and easy decision making through scoring functionality (Lan, Zhang, Lu & Wu, 2016). Fig. 2 explains the experimental approach of TM with sentiment analysis in real-time medical practice.

All the corpus words are compared with lexicon words, and the overall corpus sentiment score will be the difference between positive and negative assigned words. Thus, the polarity score of each diagnostic comment in the corpus is defined as

Sentiment score = $\sum_{j=1}^{n} \mathrm{Ps} - \sum_{k=1}^{n} \mathrm{Ns}$; Ps and N_s denote positive and negative signs
If sentiment score>0, the overall diagnosis outcome has positive
If sentiment score<0, the overall diagnosis outcome has negative
If sentiment score=0, overall diagnosis outcome has neutral

3.4.2. ML-based sentiment classification

In this study, sentiment classification was done through the Naïve Bayes classifier. It is a simple probabilistic classifier that works on Bayes theorem (Yaacob, Nasir, Yaacob & Sobri, 2019) and remains popular for text categorization, document evolution based on a characteristic of term frequency (t_f). It is one of the most popular among ML algorithms as it requires a small amount of trained data to estimate parameters required for classification. The basic idea behind Naïve Bayes' algorithm is to estimate category probabilities given in a text document through combined categorical probabilities and syntax is expressed below.

consider training dataset X for classes positive and negative
calculate the prior probability
For class positive = $\frac{\text{number of positive terms}}{\text{Total terms}}$
And
For class negative = $\frac{\text{number of negative terms}}{\text{Total terms}}$
calculate the total number of word frequencies (n_i) for both classes A(n_a) and B(n_b)
calculate the conditional probability of keyword occurrence
P (w_1/class positive) = word count/ n_i (positive)
P (w_1/class negative) = word count/ n_i (negative)....................
P (w_{n-1}/class positive) = word count/ n_i (positive)
P (w_n/class positive) = word count/ n_i (negative)
Perform uniform distribution to avoid the zero-frequency problem
New document Z is classifies based on probability of both positive and negative groups P(Z/W)
$\mathrm{P}(\frac{\text{Positive}}{\text{W}}) = P(\text{positive}) * \mathrm{P}(\frac{\text{Word1}}{\text{Class Positive}}) * \mathrm{P}(\frac{\text{Word2}}{\text{Class Positive}}) \ldots\ldots\ldots\ldots * \mathrm{P}(\frac{\text{Wordn}}{\text{Class Positive}})$
$\mathrm{P}(\frac{\text{Negative}}{\text{W}}) = P(\text{negative}) * \mathrm{P}(\frac{\text{Word1}}{\text{Class negaive}}) * \mathrm{P}(\frac{\text{Word2}}{\text{Class negaative}}) \ldots\ldots\ldots * \mathrm{P}(\frac{\text{Wordn}}{\text{Class negative}})$
The class with the highest probability is the one new document Z has assigned

4. Results

4.1. Text mining of patient documents

A random collection of patient documents with seafarer's medical problems was done. Over the total corpus, we initiate tokenization, stop words and white space removal, and lower-case conversion to extract only individual symptomatic data sets. Thereafter, symptoms were represented by the collection of diagnostic word model with (t_f - id_f) weighing method to produce a sparse matrix that limits the outcome of at least three characters of diagnosis length. The sparse matrix removed 99% of sparse terms (Refer Table 2) and Fig. 3 presents the term frequency of symptom words (i.e., each word appears at least ten times; $w \geq 10$) over three-year patient documents. The highest number of symptom occurrences was generated with library package ggplot2, which also determines the relationship of individual terms of a specific diagnosis.

As mentioned, association functionality largely depends on the correlation of given terms and outcome diagnosis. Table 3 presents the association functions of swelling, pain, and abdominal problems are having the highest correlation of at least 96%. Correlation value limits between 0 (lower band) to 1 (higher band).

4.2. Word clouds

Text mining methods allow highlighting the high-frequency terms in documents or text paragraphs. World cloud or text cloud is a visual

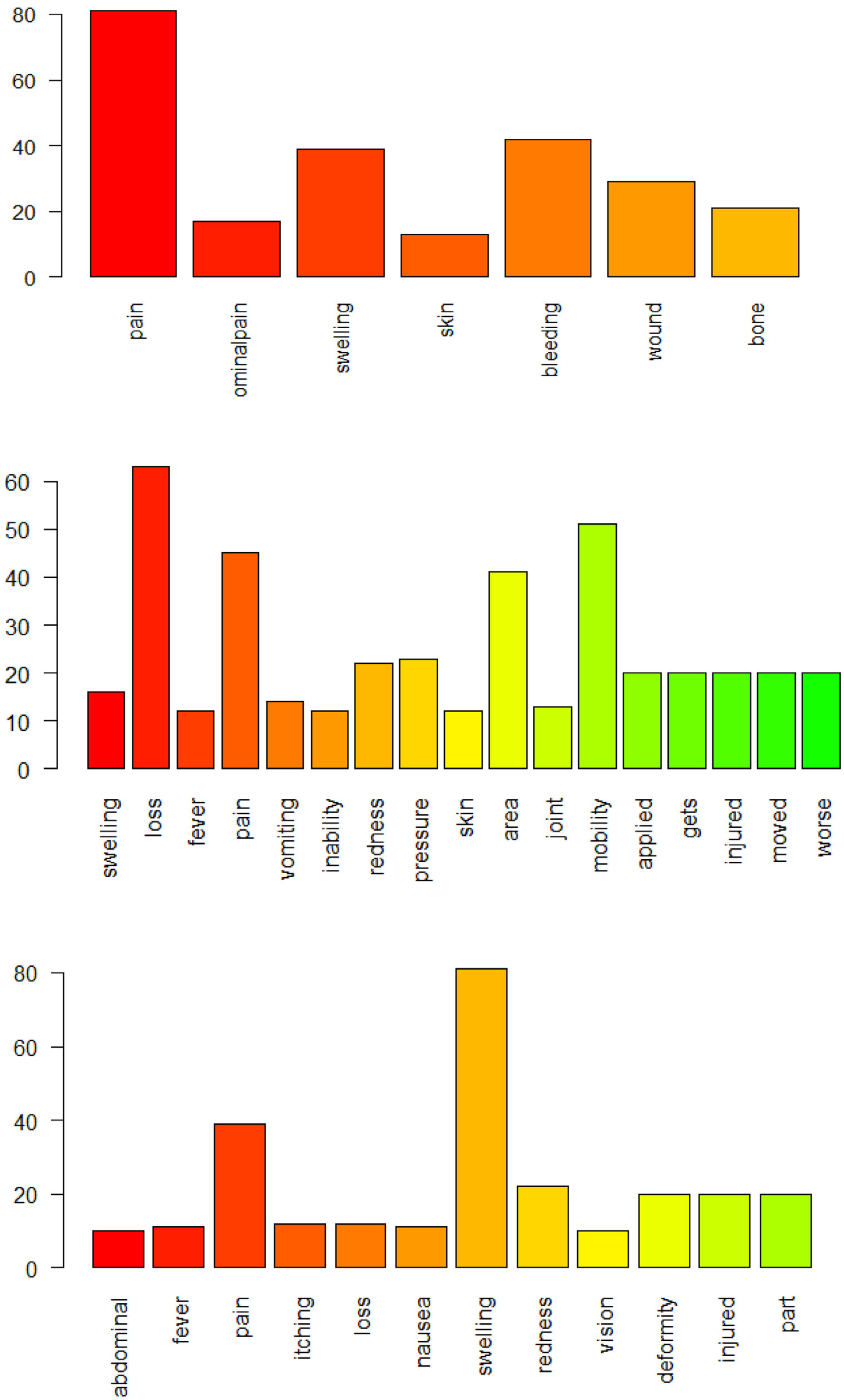

Fig. 3. Bar plot diagrams of highest frequency terms in three document groups (2018: top, 2019: middle, 2020: bottom).

representation of text data. These are visually engaging than manual data presentation. The three-year symptomatic (terms) word clouds of medical records are depicted in Fig. 4.

It is clear from the word cloud outcome, that most alignments of medical records are related to pain, swelling, bleeding, injuries, wounds, skin diseases, fever, abdominal pain, etc. In general, no seafarer is not likely to hurt himself or want to have injuries while working on merchant ships (Hystad, Nielsen & Eid, 2017). It is most common to have accidents during workplaces as a result of human errors, even if people follow preventive measures.

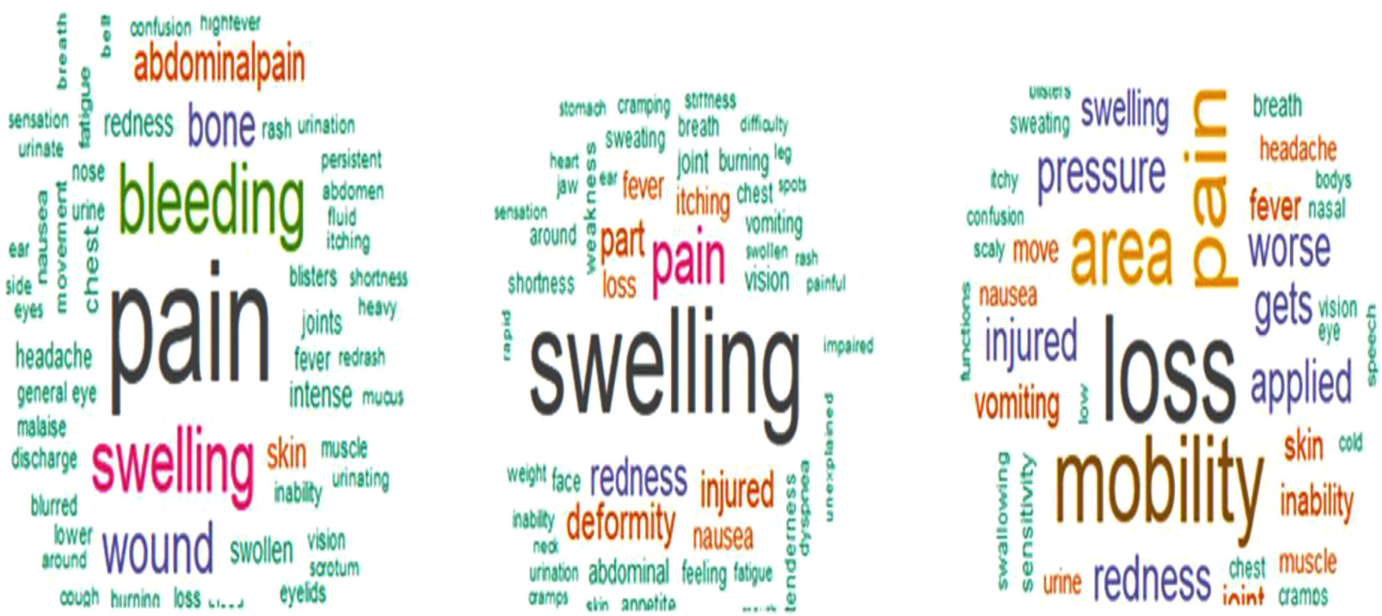

Fig. 4. Commonality word clouds of frequently occurred health problem terms (2018: left, 2019: middle, 2020: right).

Table 4
Summary of collected patient symptoms among retrieved documents.

Symptom group	Total number of documents Retrieved	Total number of patients symptoms
2018	1002	937
2019	1136	951
2020	974	889

Table 5
Sentiment scoring distribution of individual document groups (scores between −1 to 1 range considered as neutral opinion).

Score	Negative	Neutral	Positive	Row Total
2018 group	226	236	453	915
2019 group	161	399	413	973
2020 group	136	404	349	889
Total	523	1039	1215	2777

4.3. Sentiment analysis outcome

At first, we retrieved the patient documents, and then symptomatic extraction was done. Later, patient feedback is considered to conduct opinion-mining for defining positive, negative, and neutral sentiments. Thereafter, symptom frequency analysis was evaluated to identify popular disease terms and create their preassembled lexicon. Table 4 summarizes collected patient documents and symptoms. The preassembled lexicon was merged with medical library terms for sentiment classification. Lexicon scoring was performed over three sentiment groups (Fig. 5). The distribution of these scores can be observed in Table 5.

Overall sentiment of total three-year groups (2018, 2019, and 2020) has been positively achieved, with sentiment ratios (-ve: neutral: +ve) of 1:1:2, 1:2:2.5, and 1:3:2.5 respectively. All these outcomes explain patient comments about disease explanation are frequently matched positively with physician diagnosis.

In machine learning sentiment analysis, accuracy, precision, and recall were used to estimate the performance of opinion mining. Accuracy is defined as overall true outcomes of certain group model sentiments, and precision is the ratio of true positive sentiments to total sentiments of a particular group (Battineni, Sagaro, Nalini, Amenta & Tayebati, 2019). The performance metrics of the Naïve Bayes classifier on three document groups in a five-round experimental setup are indicated in Table 6.

A similar study of opinion mining to predict drug satisfaction levels among patients who experienced the effect of the drug was performed (Gopalakrishnan & Ramaswamy, 2017). They applied neural networks (NN), and support vectors (SVM) to illustrate the performance of two different drug groups. Radial basis neural networks produce better performance than SVM with an average precision of 88.6% for drug 1 and 89.8% for drug 2. In this study, we achieved over 80% of mean accuracy and precision that is well accepted in the medical domain.

5. Discussion

This study presents the importance of TM approaches in extracting clinical symptomatic information of seafarers, and patient condition and feedback were assessed through sentimental analysis. Because of the large medical data available either online or in clinical practices, it is difficult or a long-lasting process through conventional statistical methods to figure out accurate health data. On the other hand, online blogs or social media sites are not intended to disclose personal information due to low access, and privacy issues (Battineni et al., 2020). Hence, text mining methods are used to handle the clinical data and explore healthcare topics. TM is also helpful to rise the medical issues and patient opinion, and it is a special domain in exploratory analysis of text (Grover & Kar, 2017).

5.1. Contributions to literature

In medical communities, disease-related symptoms, health-related topics, and medical issues are mandatory for healthcare centers, physicians, and patients. The data availability thorough different platforms can change the study behavior of Information Systems (IS). This is high-

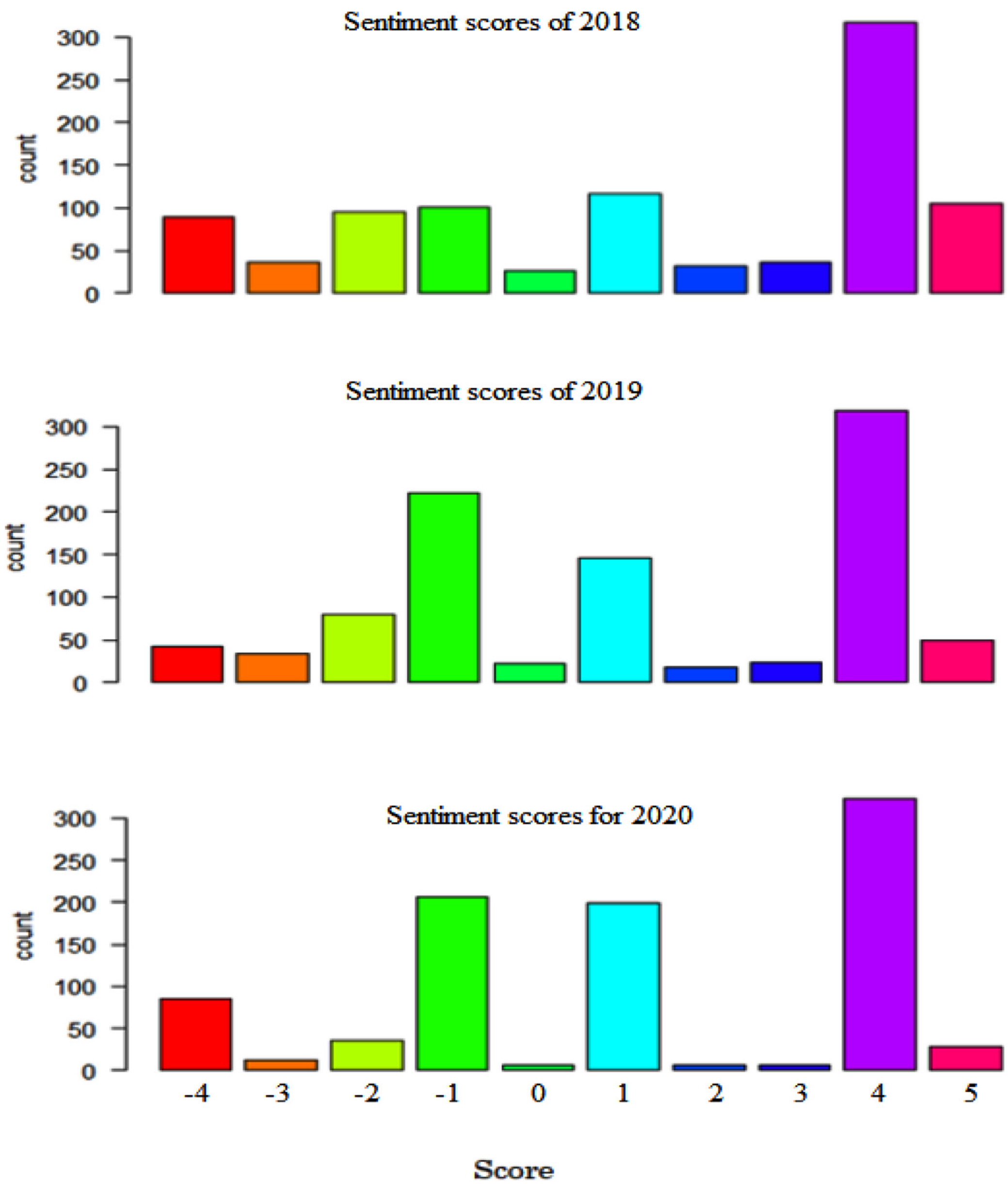

Fig. 5. Comparison of three symptom sentiment score groups [scale ranging from −5 (highly negative) to +5 (highly positive)].

Table 6
Accuracy comparison over entire corpus test patient group comments.

Experiment Number	Trained Patient comments	Negative Accuracy (%)	Precision (%)	Recall (%)	Neutral Accuracy (%)	Precision (%)	Recall (%)	Positive Accuracy (%)	Precision (%)	Recall (%)
1	10	51.2	52.3	50.6	53.7	52.9	53.1	50.4	51.2	53.2
2	20	58.1	61.8	62.4	60.2	63.6	62.4	57.3	59.8	58.3
3	30	64.8	63.1	64.6	67.4	69.1	68.7	63.1	60.6	62.6
4	50	74.9	76.2	75.2	76.6	73.2	74.3	73.3	76.1	71.8
5	100	83.6	80.3	81.6	85.4	87.8	86.8	81.7	82.4	83.4

lighted in Kar and Dwivedi (2020), described that text mining, sentimental analysis, image analytics and network science describe the insights of data science. The huge number of social media sites like Twitter or Facebook includes sentiment-based comments. To analyze this, opinion mining involves the TM to classify or evaluate the text source of sentimental content. Preliminary studies have highlighted the medical sentiments of clinical trials and online blog sources, also social media texts suggesting that they can capture the patient opinion in medical settings (Denecke & Deng, 2015). In an online medical society or social media networks, and healthcare organizations creates data, and they need patient's opinion for their sites. During the Arab spring event, TM with sentimental analysis can be a powerful predictive tool and successfully applies to extract social media events for sentiment classification (Akaichi, Dhouioui & Lopez-Huertas, 2013). In medical domain, sentiments with natural language models can classify patient comments on hospital experience.

Several studies were identified with the inclusion of sentimental analysis to find fraudulent information among health tweets. Some authors have developed a method that makes it easy to predict and analyze health issues over social sites, and results highlight the correlation accuracy between HIV ailments is 98% (Mittal, Iqbaldeep, Pandey, Verma & Goyal, 2018). A standard model in the analysis of medical user opinion depends on the information available in social media was developed (Yang, Lee & Kuo, 2016). Detection of multiple forms of medical sentiments is useful because of the possible interference with a patient medical condition, medication, and treatment. Another study has suggested that the level of SA may depend on ontology's in diabetes (Salas-Zárate et al., 2017), authors adopted corpus from Twitter and labeled user option as positive, negative, and neutral, and achieved 82% of precision.

In this paper, we achieved a 96% of correlation between symptoms and diagnosis outcome with an imbalanced dataset. The sentiment analysis was validated with Naïve Bayes and produced over 80% of accuracy, precision, and recall. In our opinion, this study is an initiative for better understanding of seafarers' problems and allow other researchers to investigate this topic in maritime medicine.

5.2. Implications to practice

Seafarers are exposed to an environment of 24/7 stay duration onboard, which addresses some facts that can affect mental health. Some of these factors can be controlled over time, but others cannot be treated (Thomas, Sampson & Zhao, 2003). Therefore, understanding disease trends are relevant in obtaining positive implications. Although, safety has to be improved at workplaces, since seafarers undergo more occupational injuries, when compared with ashore workers (Fabiano et al., 2004). It is important to follow some preventive methods to overcome the accident rate onboard. Many researchers were tried to investigate the reasons behind occupational injuries at merchant ships and identify risk factors. In the research of Hansen, Nielsen & Frydenberg (2002), 209 among 1993 accidental cases were reported with permanent disability (of 5% or more), age was considered as a major risk factor of permanent disability. Besides, seafarers are away from home and had little contact with their friends and family (Hystad en & Eid, 2016). Cultural diversity between individual workers can make it more challenging to build good relationships, and consequently, it makes them feel more isolated (Håvold, 2007).

Textual analytics strategies in medical care are generally used to process medical text contents. In the past, medical texts were targeted on patient condition and diagnosis description. Contemporarily, user-generated clinical textual content either online blogs or social media contents is explored with opinion mining (Feinerer, Hornik & Meyer, 2008). TM techniques to this seafarer's medical text enables knowledge discovery that focus among marine community works. There are some reasons behind the involvement of doctors and patients in online communities, considering the fact of many doctors are not available to explain in-depth knowledge of patient symptoms and causes. Therefore, online communities like Twitter are highly effective for doctors and patients to have healthy decisions and benefit from medical treatment from information management and peers of social media sites.

6. Conclusion

We extracted three-year patient records to understand patient views and experiences through TM and sentimental analysis. This paper presents the intervention of TM on real-time medical records of seafarers and evaluated the performance of sentiment classification in terms lexicon scoring, and machine learning models. It provided a great advantage to healthcare centers like C.I.R.M for better understanding and visualization of seafarer's problems, monitor health records, and assess patient feedback. Accidents and gastrointestinal pathologies are commonly reported by seafarers, and it can be largely projecting through symptom aliments in word clouds.

Author contributions

Conceptualization, G.B. and N.C.; methodology, G.B.; formal analysis, N.C.; investigation and experiments, N.C.; resources, G.B. and G.G.S.; data curation, G.B. and N.C.; writing—original draft preparation, G.B.; writing—review and editing, G.B. and F.A.; supervision, F.A.; project administration, F.A.; funding acquisition, F.A.

Declaration of Competing Interest

The authors declare no conflict of interest.

Funding

This work is partly supported by a grant of the ITF Trust (No. 1276/2018) for the epidemiological analysis and data mining operations.

References

Ádám, B., Rasmussen, H. B., Pedersen, R. N. F., & Jepsen, en J. R. (2014). Occupational accidents in the Danish merchant fleet and the nationality of seafarers. *Journal of Occupational Medicine and Toxicology*. 10.1186/s12995-014-0035-4.

Akaichi, J., Dhouioui, Z., & en Lopez-Huertas, M.J. (2013). Perez, "Text mining facebook status updates for sentiment classification",, doi:10.1109/ICSTCC.2013.6689032.

Bal, E., Arslan, O., & Tavacioglu, L. (2015). Prioritization of the causal factors of fatigue in seafarers and measurement of fatigue with the application of the lactate test. *Safety Science*. 10.1016/j.ssci.2014.08.003.

Battineni, G., et al. (2020a). Factors affecting the quality and reliability of online health information. *Digial Health, 6*, bll 1–11. 10.1177/2055207620948996.

Battineni, G., Di Canio, M., Chintalapudi, N., Amenta, F., & Nittari, G. (2019a). Development of physical training smartphone application to maintain fitness levels in seafarers. *International Maritime Health*. 10.5603/IMH.2019.0028.

Battineni, G., Sagaro, G. G., Chinatalapudi, N., & Amenta, F. (2020b). Applications of machine learning predictive models in the chronic disease diagnosis. *Journal of Personalized Medicine*. 10.3390/jpm10020021.

Battineni, G., Sagaro, G.G., .Nalini, C., Amenta, F., & en Tayebati, S.K. (.2019)."Comparative machine-learning approach: A follow-up study on type 2 diabetes predictions by cross-validation methods", *Machines*, doi:10.3390/machines7040074

Çakir, E. (2019). Fatal and serious injuries on board merchant cargo ships. *International Maritime Health, 70*(2), bll 113–118. 10.5603/IMH.2019.0018.

Denecke, K., & Deng, Y. (2015). Sentiment analysis in medical settings: New opportunities and challenges. *Artificial Intelligence in Medicine*. 10.1016/j.artmed.2015.03.006.

Fabiano, B., Currò, F., & Pastorino, R. (2004). A study of the relationship between occupational injuries and firm size and type in the Italian industry. *Safety Science*. 10.1016/j.ssci.2003.09.003.

Feinerer, I., Hornik, K., & Meyer, D. (2008). Text mining infrastructure in R. *Journal of Statistical Software*. 10.18637/jss.v025.i05.

Friedman, C., Rindflesch, T. C., & Corn, M. (2013). Natural language processing: State of the art and prospects for significant progress, a workshop sponsored by the National Library of Medicine. *The Journal of Biomedical Informatics*. 10.1016/j.jbi.2013.06.004.

Gopalakrishnan, V., & Ramaswamy, C. (2017). Patient opinion mining to analyze drugs satisfaction using supervised learning. *The Journal of Applied Research and Technology*. 10.1016/j.jart.2017.02.005.

Grover, P., & Kar, A. K. (2017). Big data analytics: A review on theoretical contributions and tools used in literature. *The Global Journal of Flexible Systems Management*. 10.1007/s40171-017-0159-3.

Hansen, H. L., Nielsen, D., & Frydenberg, M. (2002). Occupational accidents aboard merchant ships. *Occupational and Environmental Medicine*. 10.1136/oem.59.2.85.

Håvold, J.I. (.2007)."National cultures and safety orientation: A study of seafarers working for Norwegian shipping companies", *Work Stress*, doi:10.1080/02678370701424594.

Hystad en, S.W., .& Eid, J. (2016)."Sleep and fatigue among seafarers: The role of environmental stressors, duration at sea and psychological capital", *Safety and Health at Work*, doi:10.1016/j.shaw.2016.05.006.

Hystad, S. W., Nielsen, M. B., & Eid, J. (2017). The impact of sleep quality, fatigue and safety climate on the perceptions of accident risk among seafarers. *European Review of Applied Psychology*. 10.1016/j.erap.2017.08.003.

Kar, A. K., & Dwivedi, Y. K. (2020). Theory building with big data-driven research – Moving away from the 'What' towards the 'Why'. *The International Journal of Information Management*. 10.1016/j.ijinfomgt.2020.102205.

Khadjeh Nassirtoussi, A., Aghabozorgi, S., Wah, T.Ying, & en Ngo, D.C.L. (2014)."Text mining for market prediction: A systematic review", *Expert Systems with Applications*., doi:10.1016/j.eswa.2014.06.009.

Kim, J. H., & Jang, S. N. (2018). Seafarers' quality of life: Organizational culture, self-efficacy, and perceived fatigue. *International Journal of Environmental Research and Public Health, 15*(10). 10.3390/ijerph15102150.

Kim, Y. M., & Delen, D. (2018). Medical informatics research trend analysis: A text mining approach. *Health Informatics Journal*. 10.1177/1460458216678443.

Kostoff, R. N., Toothman, D. R., Eberhart, H. J., & Humenik, J. A. (2001). Text mining using database tomography and bibliometrics: A review. *Technological Forecasting and Social Change*. 10.1016/S0040-1625(01)00133-0.

Kukafka, R., Bales, M. E., Burkhardt, A., & Friedman, C. (2006). Human and automated coding of rehabilitation discharge summaries according to the international classification of functioning, disability, and health. *The Journal of the American Medical Informatics Association*. 10.1197/jamia.M2107.

Lan, M., Zhang, Z., Lu, Y., & en Wu, J. (2016).“Three convolutional neural network-based models for learning sentiment word vectors towards sentiment analysis”,, doi:10.1109/IJCNN.2016.7727604.

Mahdi, S. S., & Amenta, F. (2016). Eighty years of CIRM. A journey of commitment and dedication in providing maritime medical assistance. *International Maritime Health*. 10.5603/IMH.2016.0036.

Mellbye, A., & Carter, T. (2017). Seafarers' depression and suicide”. *International Maritime Health*. 10.5603/IMH.2017.0020.

Mittal, M., Iqbaldeep, K., Pandey, S. C., Verma, A., & Goyal, L. M. (2018). Opinion mining for the tweets in healthcare sector using fuzzy association rule. *EAI Endorsed Transactions on Pervasive Health and Technology*. 10.4108/eai.13-7-2018.159861.

Nittari, G., et al. (2019). Design and evolution of the Seafarer's health passport for supporting (tele)-medical assistance to seafarers. *International Maritime Health*. 10.5603/IMH.2019.0024.

Oldenburg, M., Baur, X., & Schlaich, C. (2010). Occupational risks and challenges of seafaring. *Journal of Occupational Health*. 10.1539/joh.K10004.

Penz, J. F. E., Wilcox, A. B., & Hurdle, J. F. (2007). Automated identification of adverse events related to central venous catheters. *The Journal of Biomedical Informatics*. 10.1016/j.jbi.2006.06.003.

Rathore, A.K., .Kar, A.K., .& en Ilavarasan, P.V. (.2017).“Social media analytics: Literature review and directions for future research”, *Decision Analysis*., doi:10.1287/deca.2017.0355

Salas-Zárate, M. D. P., Medina-Moreira, J., Lagos-Ortiz, K., Luna-Aveiga, H., Rodríguez-García, M. Á., & Valencia-García, R. (2017). Sentiment analysis on tweets about diabetes: An aspect-level approach. *Computational and Mathematical Methods in Medicine*. 10.1155/2017/5140631.

Shafiei, M. et al.,(2007). “Document representation and dimension reduction for text clustering”,, doi:10.1109/ICDEW.2007.4401066.

Stusser, R. J., & Dickey, R. A. (2013). Quality and cost improvement of healthcare via complementary measurement and diagnosis of patient general health outcome using electronic health record data: Research rationale and design. *The Journal of Medical Systems*. 10.1007/s10916-013-9977-9.

Thomas, M., Sampson, H., & Zhao, M. (2003). Finding a balance: Companies, seafarers and family life. *Maritime Policy & Management*. 10.1080/0308883032000051630.

Uysal, A. K., & Gunal, S. (2014). The impact of preprocessing on text classification. *Information Processing and Management*. 10.1016/j.ipm.2013.08.006.

Wadsworth, E. J. K., Allen, P. H., Wellens, B. T., McNamara, R. L., & Smith, A. P. (2006). Patterns of fatigue among seafarers during a tour of duty. *American Journal of Industrial Medicine*. 10.1002/ajim.20381.

Westlund, K., Attvall, S., Nilsson, R., & Jensen, O. C. (2016). Telemedical Maritime Assistance Service (TMAS) to Swedish merchant and passengers ships 1997–2012. *International Maritime Health*. 10.5603/IMH.2016.0006.

Yaacob, W. F. W., Nasir, S. A. M., Yaacob, W. F. W., & Sobri, N. M. (2019). Supervised data mining approach for predicting student performance. *Indonesian Journal of Electrical Engineering and Computer Science*. 10.11591/ijeecs.v16.i3.pp1584-1592.

Yang, F. C., Lee, A. J. T., & Kuo, S. C. (2016). Mining health social media with sentiment analysis. *The Journal of Medical Systems*. 10.1007/s10916-016-0604-4.

Zaman, I., Pazouki, K., Norman, R., Younessi, S., & en Coleman, S. (2017).“Challenges and opportunities of big data analytics for upcoming regulations and future transformation of the shipping industry”,, doi:10.1016/j.proeng.2017.08.182.

Zhang en, P., & Zhao, M. (2017).“Maritime health of Chinese seafarers”, *Marine Policy*,, doi:10.1016/j.marpol.2017.06.028.

Zhang, Y., Chen, M., & Liu, L. (2015). A review on text mining. In *Proceedings of the IEEE international conference on software engineering and service sciences, ICSESS: 2015* (pp. bll 681–685). Nov. 10.1109/ICSESS.2015.7339149.

Zytoon, M. A., & Basahel, A. M. (2017). Occupational safety and health conditions aboard small- and medium-size fishing vessels: Differences among age groups. *International Journal of Environmental Research and Public Health*. 10.3390/ijerph14030229.