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Importance and applicability analysis of the health and safety measures taken against the coronavirus disease on merchant vessels

Tuba KEÇECİ

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Istanbul Technical University, Faculty of Maritime, Department of Maritime Transportation Management Engineering, Istanbul, Türkiye

ORCID IDs of the author(s):
T.K. 0000-0001-6259-3858

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Correspondence:
Tuba KEÇECİ
E-mail: kececit@itu.edu.tr

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ABSTRACT

The coronavirus (COVID-19) outbreak has affected seafarers worldwide. This paper demonstrates the measures taken to prevent the spread of the coronavirus on merchant ships and evaluates them in terms of importance and applicability. Contamination reducing measures were determined through expert opinion and literature review. While their importance values were calculated using the fuzzy analytic hierarchy process method in which the total integral value with optimism index was applied, the applicability levels were revealed using a five-point Likert scale. The imbalance in rest and working hours was clearly seen in the results. Immune system protective measures were the most critical measures; however, two of them have the lowest applicability value among all criteria. They were followed by the measures taken through training, the measures to be applied in case of personnel showing disease symptoms, and the temperature measurement. In terms of the ship locations and ship operations, maintaining physical distance on deck at the port was found more critical. Its applicability level was slightly below average. This paper is the first study in the literature in which the measures taken to prevent the spread of the coronavirus pandemic on merchant ships were demonstrated in detail and evaluated with scientific methods in terms of importance and applicability. The research findings will help companies in the risk assessment process and contribute to the enhancement of the preparedness of the maritime industry for such situations by helping to protect the seafarers' health and safety.

Keywords: COVID-19, Fuzzy MCDM, Health and Safety, Maritime transportation, Seafarer, Virus disease outbreak

Introduction

The COVID-19 (coronavirus disease 2019) Pandemic, which has become a major global health threat, has infected more than 400 million people and caused the death of 5,798,628 people as of February 10, 2022 (Worldometer, n.d.). Within the pandemic period, to prevent the spread of the coronavirus, alternative forms of work such as rotational work and remote work have been adopted in some workplaces. Employees who have to continue working have faced many risks and problems. Seafarers, who have an essential role in the transportation of goods, energy, food, medicine, and many other products vital for daily needs, to all parts of the world, are also one of the groups of workers who have to continue to work. Crew changeovers and repatriation, restrictions on border crossings with border closures, abandonment, resupply and ship surveys, renewals of certificates and licensing of seafarers, and quarantine requirements were serious challenges seafarers faced during the pandemic (Doumbia-Henry, 2020). Besides governments, the International Maritime Organization (IMO), World Health Organization (WHO), International Labor Organization (ILO), the International Transport Workers Federation (ITF), the International Chamber of Shipping (ICS), the International Seafarer's Welfare Association (ISWAN), the International Maritime Health Association (IMHA), and many more organizations have worked to minimize the risk for global trade and human health (Doumbia-Henry, 2020; Stannard, 2020).

No study has been encountered yet in the literature that clearly provides information on the number of ships with COVID-19 cases and the number of seafarers infected with the coronavirus. The British Registered Diamond Princess was the first cruise ship to have coronavirus outbreak on board (Dahl, 2020). On March 8, 2020, it was found that 696 of the 3,711 people on the Diamond Princess cruise ship tested positive for SARS-CoV-2, and seven patients died, while less than twenty days later, it was confirmed that there were COVID-19 cases on 25 more cruise ships (Xu et al., 2020). However, apart from cruise ships, there is no clear information on the number of infected seafarers in merchant ships and fishing vessels. It was known that five crew members caught the coronavirus on the Danish container ship Gjertrud Maersk, which anchored in Zhoushan Port on March 17, 2020 (Dai et al., 2020). Additionally, it was known that there were cases on board ships in Brazil, Antwerp, and Mozambique, and some of these have unfortunately led to the death of seafarers (Stannard, 2020; The Hindu, n.d.).

Under the International Safety Management Code (ISM Code), shipping companies are required to define risks and assess them to ensure the safety of their ships, the environment, and personnel (IMO, 2010). In the light of the risk assessment carried out, the procedure for seafarers' health and safety should be developed and added to the company's Safety Management System (SMS). In the pandemic period, safety procedures including precautions specific to conditions were developed to ensure the safety of seafarers and ship operations' safety and minimize risks. However, due to the unique nature of the working environment on ships, it is not possible to apply some of these measures onboard. In addition, the efficiency level of all measures should be taken into account. There is no study in the literature in which the measures taken to prevent the spread of the coronavirus pandemic on merchant ships were demonstrated in detail and evaluated with scientific methods in terms of importance and applicability. In order to fill this gap, the measures taken on board ships were specified, and the importance values were determined by consulting expert opinion. Calculations were performed by using the Fuzzy Analytic Hierarchy Method (FAHP) in which the total integral value with optimism index was applied. In addition, the extent to which the determined measures are applicable on the ship were found using the five-point Likert scale. This research, which is the first study to investigate the importance and applicability of measures taken against the spread of coronavirus disease on merchant ships based on a scientific method, is an important source that can be used in the risk assessment and procedure development process for maritime companies. The study results, which will also be a reference for safety training, will contribute to the protection of seafarers' health, to ensure job safety, for the maritime industry to become aware of its current state, and to increase its preparedness for such situations.

Protection Measures and Management of Covid-19 Onboard

Under Article IV, paragraphs 1 and 4 of the MLC, 2006, every seafarer has the right to a safe and secure working environment and protection of health, medical care, and well-being. Some recommendations on measures to be taken to protect seafarers, who were recognized as key workers by 45 IMO member states and one associate member country in 2020, have been published during the coronavirus outbreak. ILO has published an information note on maritime labor issues and coronavirus on April 7, 2020 (ILO, 2020). The document emphasizes that flag states should take the necessary measures to protect the seafarers' health on ships flying their flags and ensure that they have access to adequate medical care, including the provision of personal protective equipment and disinfectants, especially during the COVID-19 pandemic (ILO, 2020). In the interim guidance titled 'Operational considerations for managing COVID-19 cases and outbreaks onboard ships' (WHO, 2020a) published by WHO on February 24, 2020, recommendations for seafarers, ship owners, and maritime authorities were presented. In this guide, which was encouraged to be used with the guide titled 'Handbook for management of public health events onboard ships' (WHO, 2016), information about the outbreak management plan, precautions to be taken before boarding the ship, and measures for managing suspicious cases were given. The points to be considered during the quarantine period in case of COVID-19 case detection, the adequacy of the amount of personal protective equipment, training, cleaning, disinfection frequency, waste management were the issues that draw attention in the guide. Another document published by WHO is the interim report titled 'Promoting public health measures in response to COVID-19 on cargo ships and fishing vessels' (WHO, 2020b). Topics mentioned in this report were minimizing the number of non-crew members boarding, hand hygiene, and respiratory etiquette, physical distancing, use of masks, managing COVID-19 cases and their contacts, access to medical facilities, digital tools, and mobile applications, training, mental health and psychosocial support, and public health measures for shore-side visits. ICS has published Coronavirus (COVID-19) Guidance for Ship Operators for the Protection of the Health of Seafarers (ICS, 2020) to help seafarers and ship operators follow health advice from United Nations agencies and other organizations. Measures to be taken to protect from infection were stated as monitoring and screening, using personal protective equipment (PPE), testing and assessment, shipboard self-distancing (SSD), and cleaning and disinfection. It has been emphasized that the training recommended for hand and respiratory hygiene is of vital importance. Minimizing interaction with shore personnel during port operations, giving health-self declaration, regular temperature measurement, frequent disinfection of equipment, using stairs outside the accommodation whenever possible, eating meals in the cabin, trying to spend rest hours in the cabin, getting enough sleep, paying attention to healthy nutrition, using masks, hanging informative posters, giving importance to mental health and adhering to promoting cough etiquette were among the measures mentioned in this document.

Besides the organizations mentioned above, country-specific organizations also provide preventive measures. Minimizing shore leave, avoiding touching face with unwashed hands, and monitoring of crew for signs and symptoms of coronavirus were some of the recommendations presented in the interim guidance (CDC, 2020) prepared by the Centres for Disease Control and Prevention, one of these organizations, on the management of suspected coronavirus cases. The other measures stated in this document were avoiding sharing personal items such as laptops and other hand-held devices and blankets, encouraging the use of non-contact methods of greeting, wearing a facemask, assigning crew to single-occupancy cabins with private bathrooms, placing hand sanitizer in multiple locations and ensuring handwashing facilities are well stocked with paper towels, soap, and a waste receptacle. The CDC also makes recommendations for maritime pilots to protect themselves and slow the spread of coronavirus. Using external stairs to access the vessel bridge, reminding the master to limit the crew involved in vessel navigation while the pilot is on board, using personal hand sanitizer, cleaning and disinfecting portable pilot units, radios etc. after each pilot job, wearing a face shield and avoiding contact with frequently touched bridge surfaces unless it is necessary were noteworthy measures in the document.

Shipping companies determine their own safety measures in addition to the measures stated in the guidelines and resources mentioned in this section for the implementation of protection measures related to coronavirus on their ships. All the measures certainly have an essential role in reducing the risk of coronavirus transmission. However, due to the unique nature of ship operations, not all preventive health and safety measures taken on the ship will be equally applicable, and their effectiveness in preventing the spread of the virus will also be different. Measuring the importance and applicability of the precautions taken in this critical period will be beneficial to ship operators and seafarers in risk assessment studies and in taking additional measures. For this purpose, taking into account ship locations and ship operations, the measures discussed in this section were examined. The measures that were compiled by removing repetitive ones were evaluated after being combined with the safety measures obtained from expert opinions.

Material and Methods

The criteria were determined by reviewing the resources mentioned in the previous section. All measures were presented in a hierarchical structure in the Results and Discussion section. Six maritime experts scored the importance of each measure in preventing the risk of coronavirus transmission. Among those experts, five keep the license of Ocean-going Ship Master, and one keeps the Ocean-going Chief Officer license. While four experts served on the ship, one worked as Executive Director (fleet operations) during this study. The average service period of experts was 11 years. The types of ships that they worked on were container ships, chemical tankers, bulk carriers, dry cargo vessels, and Ro-Ro ships. The fact that the experts who worked on the ship during the coronavirus outbreak worked on different ship types was valuable in that the results of this study would cover different ship types. Scoring aimed to reveal the rankings of measures by comparing them. Analytic Hierarchy Process (AHP) technique (Saaty, 1980) was chosen as the multi-criteria decision-making technique to emergein this order. Fuzzy set theory (Zadeh, 1965) was used to add blurriness in the mentality of experts to this technique in which crisp values were used. The total integral value with optimism index (Liou and Wang, 1992) was used with FAHP to get more reliable results. During the analysis process, an MS excel file in which the application steps of the method were formulated was used for calculations. The 9-point evaluation scale was used to collect expert judgments, and the scale which is given in Table 1 was used in fuzzy AHP calculations. The mean of expert opinions was calculated by the geometric mean method.

Table 1. Fuzzy Evaluation Scale (Yuen and Lau, 2011)

Fuzzy value	Fuzzy Reciprocal value
(8,9,9)	(1/9,1/9,1/8)
(7,8,9)	(1/9,1/8,1/7)
(6,7,8)	(1/8,1/7,1/6)
(5,6,7)	(1/7,1/6,1/5)
(4,5,6)	(1/6,1/5,1/4)
(3,4,5)	(1/5,1/4,1/3)
(2,3,4)	(1/4,1/3,1/2)
(1,2,3)	(1/3,1/2,1)
(1,1,1)	(1,1,1)

In addition, experts were asked to rate the applicability of the protection measures on the ship. A five-point Likert scale was used in scoring. The expert opinion was obtained by the questionnaire technique.

Fuzzy AHP

Introduced to the literature by Saaty (1980), the AHP evaluation process relies on the decision maker's subjective judgment which is uncertain. The uncertainty in the mind set of the decision-maker was tried to be removed by integrating the Fuzzy logic presented in the literature by Zadeh (1965) into comparison matrices. The first study in which Fuzzy AHP was used was presented to the literature by van Laarhoven and Pedrycz (1983). Later, Buckley (1985) showed that the trapezoidal-shaped fuzzy numbers and the geometric mean method could be used in the analysis (Kwong and Bai, 2002). Then, Chang (1996) proposed a new approach to Fuzzy AHP using the extent analysis method for the synthetic extent value of the pairwise comparison. The steps of finding the synthetic extent value with the extent analysis method is given below.

A triangular fuzzy number (TFN) expresses the relative strength of each pair of elements in the same hierarchy and can be indicated as $\widetilde{M} = (l, m, u)$, where $l \leq m \leq u$, the parameters l stands for the lower value, m for the middle value, and u for the upper value (Chang, 1996; Onut et al., 2008). A triangular membership function of $\widetilde{M}$ can be calculated as in Equation (1) (Onut et.al., 2008).

$$\mu_{\widetilde{M}}(x) = \begin{cases} 0, & x < l \\ \dfrac{x-l}{m-l}, & l \leq x \leq m \\ \dfrac{u-x}{u-m}, & m \leq x \leq u \\ 0, & x > u \end{cases}$$

(1)

A triangular membership function is demonstrated in Figure 1.

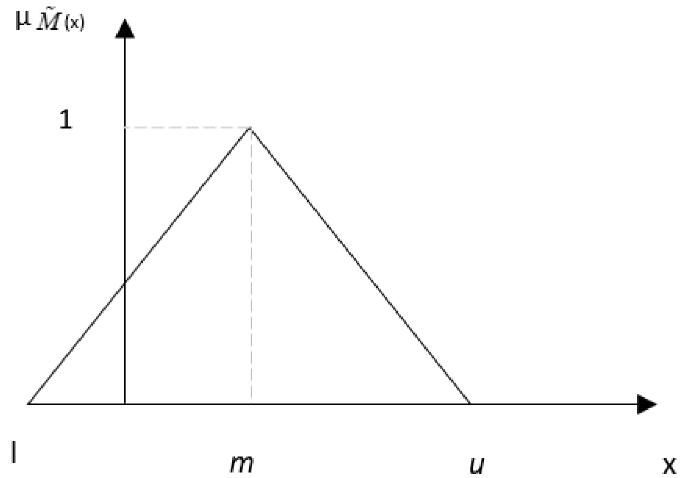

Figure 1. Triangular membership function

The application steps of the extent analysis method were detailed as follows (Chang, 1996).

Let $X = \{x_1, x_2, ..., x_n\}$ represent an object set, and $U = \{u_1, u_2, \dots, u_m\}$ be a goal set. We take each object and perform the extent analysis for each goal, respectively. We get m extent analysis values for each object, with the following signs;

$$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3 ..., M_{g_i}^m \quad , \qquad i=1, \quad 2, \quad 3..., \quad n,$$

(2) where all the $M_{g_i}^j$ (j= 1,2,3 ..., m) are TFNs.

The value of fuzzy synthetic extent with respect to the i-th object is found as (Chang, 1992),

$$S_i = \sum_{j}^{m} M_{g_i}^{j} \otimes \left[\sum_{i}^{n} \sum_{j}^{m} M_{g_i}^{j} \right]^{-1}$$

(3)

The extent analysis method sometimes causes some of the weight values to appear as zero. The total integral value method with optimism index was applied in this study in order to obtain a more reliable result since if more than one value is zero, the ranking of the criteria cannot be determined clearly.

The Total Integral Value with Optimism Index

Wang et al. (2008) express that the degree of possibility calculated by Chang's (1996) extent analysis method is an index for comparing two TFNs to show to what degree a TFN is larger than the others rather than presenting their relative importance. The total integral value with optimism index was developed by Liou and Wang (1992) to solve this problem and used in many studies (Akyildiz and Mentes, 2017; Alipour et al., 2017; Baysal and Çetin, 2018; De Felice et al., 2019; Duman et al., 2017; Flores-Carrillo et al., 2017; Şen and Çınar, 2010) in the literature. Equation 4 can derive the synthetic extent values of A.

$$I_T^{\alpha}(\widetilde{S_i}) = \frac{1}{2}\alpha(m_i + u_i) + \frac{1}{2}(1-\alpha)(l_i + m_i)$$
$$= \frac{1}{2}[\alpha u_i + m_i + (1-\alpha) l_i]$$

(4)

where $\propto$ is the index of optimism indicates the degree of optimism for decision-makers (Liou and Wang, 1992). If $\propto$ approaches 0 in the [0; 1] interval, it shows the decision-makers are more pessimistic (Şen and Çınar, 2010). For a neutral or moderately objective decision-maker, $\propto$ value equals 0.5 (Akyildiz and Mentes, 2017).

The normalized importance weight vector $W = (w_1, w_2, ..., w_n)^T$ of fuzzy matrix A can be calculated using Equation 5 (Şen and Çınar, 2010).

$$W_i = \frac{I_T^{\alpha}(\widetilde{S_i})}{\sum_i^n I_T^{\alpha}(\widetilde{S_i})}$$

(5)

In this study, the synthetic extent values were determined by using Equation (3) and integrated into the Fuzzy AHP method by applying the total integral value with the optimism index.

Results and Discussion

The measures taken on board to reduce the risk of coronavirus transmission were categorized and presented as criteria in a hierarchical structure which was given in Table 2.

The main criteria that make up the first level were determined as Physical Distancing (C_1), Hygiene Precautions (C_2), Body Temperature Screening (C_3), Immune System Protective Measures (C_4), Training (C_5), and Management of a Suspected Case of COVID-19 (C_6).

At the second level, there were sub-criteria. While determining the sub-criteria of the Physical distancing (C_1), the operational processes of the ship were taken into consideration. These processes were arrival/departure maneuvers, open sea navigation, and staying at the port during cargo handling.

The main locations of the ship were taken into consideration while determining the sub-sub criteria under Physical distancing at port (C_{11}). The areas where people interact at the port were specified as the deck, the accommodation, and the engine room. While defining the sub-sub criteria under Physical distancing during open sea navigation (C_{12}) and Physical distancing during arrival/departure maneuvers (C_{13}), the bridge area was also included among these ship locations.

Table 2. The hierarchical structure of the measures taken on board against COVID-19

Main criteria		Sub- criteria		Sub-sub criteria	
C1	Physical Distancing	C11	Physical distancing at port	C111	Physical distancing on deck
				C112	Physical distancing in the accommodation
				C113	Physical distancing in the engine room
		C12	Physical distancing during open sea navigation	C121	Physical distancingthe on bridge
				C122	Physical distancing on deck
				C123	Physical distancing in the accommodation
				C124	Physical distancing in the engine room
		C13	Physical distancing during departure-arrival manouvre	C131	Physical distancing on the bridge
				C132	Physical distancing on deck
				C133	Physical distancing in the accommodation
				C134	Physical distancing in the engine room
C2	Hygiene Precautions	C21	Personal hygiene	C211	Cleaning hands frequently
				C212	Wearing medical masks/changing as often as necessary
				C213	Using personal disinfectants
				C214	Avoiding personal protective equipment sharing
				C215	Using protective googles in case of absence of/not using a face shield
				C216	Using gloves
				C217	Using separate overalls and shoes at the port on deck and in accommodation
				C218	Using disposable coveralls, masks, gloves, and face shield while working on the deck at a risky port
		C22	Ventilation	C221	Ventilation of cabins
				C222	Ventilation of accommodation
				C223	Ventilation at port
		C23	Common area disinfection	C231	Providing disinfectants in corridors and common areas
				C232	Placing anti-bacterial soap in common toilets
				C233	Disinfection of shared devices/equipment (computer, bridge devices etc.)
		C24	Hygiene measures taken regarding visitors	C241	Cleaning the accommodation with bleach at departure from risky port
				C242	Washing the accommodation with sea water from outside at departure from risky port
				C243	Placing pans with bleach to wipe the shoes of visitors at the gangway and accommodation entrances
				C244	Daily cleaning of the areas where visitors are hosted at port
				C245	Making sure visitors (pilot, authority, dock worker etc.) are wearing masks/gloves
				C246	Making sure visitors are wearing overshoes
				C247	Providing the food service to pilots in long maneuvers with disposable materials
				C248	Entering the accommodation from a single point
		C25	Waste management	C251	Treating masks, overalls etc. as medical waste
		C26	Food safety precautions	C261	Prevention of taking food at risky ports
				C262	Proper washing of vegetables/fruits that are eaten raw
C3	Body Temperature Screening	C31	Temperature screening of ship crew twice a day		
		C32	Temperature screening of visitors		
C4	Immune System Protective Measures	C41	Getting enough sleep		
		C42	Exercise		
		C43	Eating adequate/nutritious foods		
C5	Training	C51	Providing training for ship crew on COVID-19 measures with sufficient time prior to port arrival		
		C52	Hanging informative posters on visible parts of the ship		
		C53	Training the new crew members joining the ship on COVID-19		
C6	Management of a Suspected Case of COVID-19	C61	Isolation in single-occupancy cabin		
		C62	Using dedicated or disposable dish and food service utensils		
		C63	Treating the wastes as medical waste		
		C64	Ventilation of the cabin from the light port		
		C65	Checking on the suspected person 3 times a day		
		C66	Making sure the laundry is washed by soap and water		
		C67	Regular support from medical services		

Fuzzy Integrated Total Integral Value Method Results

In this section, by integrating Liou and Wang's (1992) total integral value with optimism index into Chang's (1996)] extent analysis method, the weight vectors of the comparison matrices of the criteria in all levels of the hierarchical structure were calculated.

In the first step, fuzzy synthetic values of the main criteria were obtained using Chang's (1996) extended analysis method. For this purpose, six decision matrices belonging to experts were transformed into a single decision matrix by using the geometric mean method. The aggregated matrix is given in Table 3.

As seen in the matrix given in Table 3, the fuzzy sums of each row were calculated. Using the Equation (3), fuzzy synthetic values of the criteria were determined as S_{C1}= (0.12, 0.19, 0.29), S_{C2}= (0.09, 0.15, 0.26), S_{C3}= (0.04, 0.07, 0.11), S_{C4}= (0.12, 0.19, 0.29), S_{C5}= (0.09, 0.15, 0.26), and S_{C6}= (0.16, 0.24, 0.35).

In the second step, by following the steps of the total integral value method, the fuzzy number sequencing process was carried out with the help of the synthetic values. Considering that experts made an impartial assessment, ∝ the degree of optimism value was determined as 0.5. According to Liou and Wang's (1992) total integral value with optimism index method, using Equation 4,

(SC_1)= 0.202

(SC_2)= 0.165

(SC_3)= 0.071

(SC_4)= 0.202

(SC_5)= 0.165

(SC_6)= 0.248

were obtained. Accordingly, the weight vector of the criteria was expressed as W= (0.202, 0.165, 0.071, 0.202, 0.165, 0.248). Using the Equation 5, the normalized weight vector calculated was W= (0.192, 0.157, 0.067, 0.192, 0.157, 0.236)^T.

All calculations made for main criteria were also performed for the sub-criteria and the sub-sub-criteria. The aggregated FAHP Pairwise comparison matrix and the synthetic values obtained for the sub-criteria were given in Table 4, for the sub-sub-criteria of C_1 were given in Table 5 and for the sub-sub-criteria of C_2 were given in Table 6.

Table 3. Aggregated FAHP Pairwise Comparison Matrix for Criteria

	C_1			C_2			C_3			C_4			C_5			C_6			Total		
C_1	1.00	1.00	1.00	0.76	1.26	1.73	2.26	3.03	3.71	1.00	1.00	1.00	0.76	1.26	1.73	0.76	0.79	0.83	6.56	8.34	10.01
C_2	0.58	0.79	1.31	1.00	1.00	1.00	1.42	2.29	3.31	0.58	0.79	1.31	1.00	1.00	1.00	0.48	0.63	1.00	5.06	6.51	8.93
C_3	0.27	0.33	0.44	0.30	0.44	0.70	1.00	1.00	1.00	0.27	0.33	0.44	0.30	0.44	0.70	0.23	0.28	0.34	2.38	2.81	3.63
C_4	1.00	1.00	1.00	0.76	1.26	1.73	2.26	3.03	3.71	1.00	1.00	1.00	0.76	1.26	1.73	0.76	0.79	0.83	6.56	8.34	10.01
C_5	0.58	0.79	1.31	1.00	1.00	1.00	1.42	2.29	3.31	0.58	0.79	1.31	1.00	1.00	1.00	0.48	0.63	1.00	5.06	6.51	8.93
C_6	1.20	1.26	1.31	1.00	1.59	2.08	2.96	3.63	4.28	1.20	1.26	1.31	1.00	1.59	2.08	1.00	1.00	1.00	8.36	10.33	12.05

Table 4. The aggregated FAHP pairwise comparison matrix and the synthetic values obtained for the sub-criteria

	C_{11}			C_{12}			C_{13}			Total		
C_{11}	1.00	1,00	1,00	1,32	1,59	1,86	1,00	1,41	1,73	3,32	4,00	4,59
C_{12}	0.54	0.63	0.75	1.00	1.00	1.00	0.69	0.89	1.31	2.23	2.52	3.06
C_{13}	0.58	0.71	1.00	0.76	1.12	1.44	1.00	1.00	1.00	2.34	2.83	3.44

SC_{11}=(0.30, 0.43, 0.58), SC_{12}=(0.20, 0.27, 0.39), SC_{13}=(0.21, 0.30, 0.44).

	C_{21}			C_{22}			C_{23}			C_{24}			C_{25}			C_{26}			Total		
C_{21}	1.00	1.00	1.00	1.00	1.12	1.20	1.00	1.26	1.44	1.00	1.12	1.20	1.73	2.52	3.22	1.66	2.00	2.26	7.39	9.02	10.33
C_{22}	0.83	0.89	1.00	1.00	1.00	1.00	1.00	1.12	1.20	1.00	1.00	1.00	1.44	2.24	2.96	1.38	1.78	2.08	6.66	8.04	9.24
C_{23}	0.69	0.79	1.00	0.83	0.89	1.00	1.00	1.00	1.00	0.83	0.89	1.00	1.20	2.00	2.72	1.15	1.59	2.08	5.71	7.16	8.80
C_{24}	0.83	0.89	1.00	1.00	1.00	1.00	1.00	1.12	1.20	1.00	1.00	1.00	1.44	2.24	2.96	1.38	1.78	2.08	6.66	8.04	9.24
C_{25}	0.31	0.40	0.58	0.34	0.45	0.69	0.37	0.50	0.83	0.34	0.45	0.69	1.00	1.00	1.00	0.61	0.79	1.20	2.96	3.58	5.00
C_{26}	0.44	0.50	0.60	0.48	0.56	0.72	0.48	0.63	0.87	0.48	0.56	0.72	0.83	1.26	1.64	1.00	1.00	1.00	3.72	4.51	5.55

SC_{21}= (0.15, 0.22, 0.31), SC_{22}= (0.14, 0.20, 0.28), SC_{23}= (0.12, 0.18, 0.27), SC_{24}= (0.14, 0.20, 0.28), SC_{25}= (0.06, 0.09, 0.15), SC_{26}= (0.08, 0.11, 0.17).

	C_{31}			C_{32}			Total		
C_{31}	1.00	1.00	1.00	0.83	0.89	1.00	1.83	1.89	2.00
C_{32}	1.00	1.12	1.20	1.00	1.00	1.00	2.00	2.12	2.20

SC_{31}= (0.44, 0.47, 0.52), SC_{32}=(0.48, 0.53, 0.57).

	C_{41}			C_{42}			C_{43}			Total		
C_{41}	1.00	1.00	1.00	1.00	1.12	1.20	1.00	1.00	1.00	3.00	3.12	3.20
C_{42}	0.83	0.89	1.00	1.00	1.00	1.00	0.83	0.89	1.00	2.67	2.78	3.00
C_{43}	1.00	1.00	1.00	1.00	1.12	1.20	1.00	1.00	1.00	3.00	3.12	3.20

SC_{41}=(0.32, 0.35, 0.37), SC_{42}=(0.28, 0.31, 0.35), SC_{43}=(0.32, 0.35, 0.37).

	C_{51}			C_{52}			C_{53}			Total		
C_{51}	1.00	1.00	1.00	0.83	1.00	1.20	1.00	1.00	1.00	2.83	3.00	3.20
C_{52}	0.83	1.00	1.20	1.00	1.00	1.00	0.83	1.00	1.20	2.67	3.00	3.40
C_{53}	1.00	1.00	1.00	0.83	1.00	1.20	1.00	1.00	1.00	2.83	3.00	3.20

SC_{51}=(0.29, 0.33, 0.38), SC_{52}=(0.27, 0.33, 0.41), SC_{53}=(0.29, 0.33, 0.38).

	C_{61}			C_{62}			C_{63}			C_{64}			C_{65}			C_{66}			C_{67}			Total		
C_{61}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.20	1.38	1.78	2.08	2.17	2.40	2.61	1.20	1.26	1.31	8.76	9.57	10.20
C_{62}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.20	1.38	1.78	2.08	2.17	2.40	2.61	1.20	1.26	1.31	8.76	9.57	10.20
C_{63}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.12	1.20	1.38	1.78	2.08	2.17	2.40	2.61	1.20	1.26	1.31	8.76	9.57	10.20
C_{64}	0.83	0.89	1.00	0.83	0.89	1.00	0.83	0.89	1.00	1.00	1.00	1.00	1.31	1.70	1.99	2.05	2.29	2.50	1.00	1.12	1.31	7.86	8.78	9.80
C_{65}	0.48	0.56	0.72	0.48	0.56	0.72	0.48	0.56	0.72	0.50	0.59	0.76	1.00	1.00	1.00	1.09	1.35	1.66	0.58	0.71	0.87	4.61	5.33	6.46
C_{66}	0.38	0.42	0.46	0.38	0.42	0.46	0.38	0.42	0.46	0.40	0.44	0.49	0.60	0.74	0.92	1.00	1.00	1.00	0.50	0.52	0.55	3.65	3.95	4.34
C_{67}	0.76	0.79	0.83	0.76	0.79	0.83	0.76	0.79	0.83	0.76	0.89	1.00	1.15	1.41	1.73	1.81	1.91	1.99	1.00	1.00	1.00	7.02	7.59	8.22

SC61=(0.15, 0.18, 0.21), SC62=(0.15, 0.18, 0.21), SC63= (0.15, 0.18, 0.21), SC64=(0.13, 0.16, 0.20), SC65=(0.08, 0.10, 0.13), SC66=(0.06, 0.07, 0.09), SC67=(0.12, 0.14, 0.17).

Table 5. The aggregated FAHP pairwise comparison matrix and the synthetic values obtained for the sub-sub-criteria of C_1

	C_{111}			C_{112}			C_{113}			Total		
C_{111}	1.00	1.00	1.00	0.83	1.12	1.44	0.83	1.12	1.44	2.67	3.24	3.88
C_{112}	0.69	0.89	1.20	1.00	1.00	1.00	1.00	1.00	1.00	2.69	2.89	3.20
C_{113}	0.69	0.89	1.20	1.00	1.00	1.00	1.00	1.00	1.00	2.69	2.89	3.20

SC_{111}=(0.26, 0.36, 0.48), SC_{112}=(0.26, 0.32, 0.40), SC_{113}=(0.26, 0.32, 0.40).

	C_{121}			C_{122}			C_{123}			C_{124}			Total		
C_{121}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00	4.00	4.00
C_{122}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00	4.00	4.00
C_{123}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00	4.00	4.00
C_{124}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.00	4.00	4.00

SC_{121}= (0.25, 0.25, 0.25), SC_{122}=(0.25, 0.25, 0.25), SC_{123}=(0.25, 0.25, 0.25), SC_{124}=(0.25, 0.25, 0.25).

	C_{131}			C_{132}			C_{133}			C_{134}			Total		
C_{131}	1.00	1.00	1.00	1.00	1.78	2.50	1.78	2.50	3.17	1.00	1.78	2.50	4.78	7.06	9.17
C_{132}	0.40	0.56	1.00	1.00	1.00	1.00	1.00	1.78	2.50	1.00	1.00	1.00	3.40	4.34	5.50
C_{133}	0.31	0.40	0.56	0.40	0.56	1.00	1.00	1.00	1.00	0.40	0.56	1.00	2.12	2.52	3.56
C_{134}	0.40	0.56	1.00	1.00	1.00	1.00	1.00	1.78	2.50	1.00	1.00	1.00	3.40	4.34	5.50

SC_{131}= (0.20, 0.39, 0.67), SC_{132}=(0.14, 0.24, 0.40), SC_{133}=(0.09, 0.14, 0.26), SC_{134}=(0.14, 0.24, 0.40).

Table 6. The aggregated FAHP pairwise comparison matrix and the synthetic values obtained for the sub-sub-criteria of C_2

	C_{211}			C_{212}			C_{213}			C_{214}			C_{215}			C_{216}			C_{217}			C_{218}			Total		
C_{211}	1.00	1.00	1.00	1.38	1.59	1.73	1.31	1.51	1.66	1.20	1.26	1.31	1.31	1.70	1.99	2.50	3.03	3.46	2.30	2.52	2.72	2.17	2.40	2.61	13.17	15.01	16.48
C_{212}	0.58	0.63	0.72	1.00	1.00	1.00	0.83	0.89	1.00	0.69	0.79	0.87	0.83	1.00	1.20	1.71	2.04	2.30	1.57	1.70	1.81	1.44	1.59	1.71	8.66	9.64	10.61
C_{213}	0.60	0.66	0.76	1.00	1.12	1.20	1.00	1.00	1.00	0.72	0.83	0.92	1.00	1.12	1.20	1.71	2.29	2.76	1.57	1.91	2.17	1.44	1.78	2.05	9.05	10.72	12.07
C_{214}	0.76	0.79	0.83	1.15	1.26	1.44	1.09	1.20	1.38	1.00	1.00	1.00	1.09	1.35	1.66	2.17	2.70	3.13	1.99	2.24	2.47	1.66	2.00	2.26	10.92	12.54	14.18
C_{215}	0.50	0.59	0.76	0.83	1.00	1.20	0.83	0.89	1.00	0.60	0.74	0.92	1.00	1.00	1.00	1.71	2.04	2.30	1.31	1.70	1.99	1.20	1.59	1.89	7.99	9.55	11.06
C_{216}	0.29	0.33	0.40	0.44	0.49	0.58	0.36	0.44	0.58	0.32	0.37	0.46	0.44	0.49	0.58	1.00	1.00	1.00	0.72	0.83	0.92	0.60	0.74	0.92	4.17	4.69	5.45
C_{217}	0.37	0.40	0.44	0.55	0.59	0.64	0.46	0.52	0.64	0.41	0.45	0.50	0.50	0.59	0.76	1.09	1.20	1.38	1.00	1.00	1.00	0.83	0.89	1.00	5.21	5.64	6.36
C_{218}	0.38	0.42	0.46	0.58	0.63	0.69	0.49	0.56	0.69	0.44	0.50	0.60	0.53	0.63	0.83	1.09	1.35	1.66	1.00	1.12	1.20	1.00	1.00	1.00	5.52	6.21	7.14

SC_{211}=(0.16, 0.20, 0.25), SC_{212}=(0.10, 0.13, 0.16), SC_{213}=(0.11, 0.14, 0.19), SC_{214}=(0.13, 0.17, 0.22), SC_{215}=(0.10, 0.13, 0.17), SC_{216}=(0.05, 0.06, 0.08), SC_{217}=(0.06, 0.08, 0.10), SC_{218}=(0.07, 0.08, 0.11).

	C_{221}			C_{222}			C_{223}			Total		
C_{221}	1.00	1.00	1.00	1.00	1.00	1.00	2.37	2.88	3.31	4.37	4.88	5.31
C_{222}	1.00	1.00	1.00	1.00	1.00	1.00	2.37	2.88	3.31	4.37	4.88	5.31
C_{223}	0.30	0.35	0.42	0.30	0.35	0.42	1.00	1.00	1.00	1.60	1.69	1.85

SC_{221}=(0.35, 0.43, 0.51), SC_{222}=(0.35, 0.43, 0.51), SC_{223}=(0.13, 0.15, 0.18).

	C_{231}			C_{232}			C_{233}			Total		
C_{231}	1.00	1.00	1.00	1.00	1.12	1.20	1.31	1.35	1.38	3.31	3.47	3.58
C_{232}	0.83	0.89	1.00	1.00	1.00	1.00	1.20	1.26	1.31	3.03	3.15	3.31
C_{233}	0.72	0.74	0.76	0.76	0.79	0.83	1.00	1.00	1.00	2.49	2.54	2.60

SC_{231}=(0.35, 0.38, 0.41), SC_{232}=(0.32, 0.34, 0.37), SC_{233}=(0.26, 0.28, 0.29).

	C_{241}			C_{242}			C_{243}			C_{244}			C_{245}			C_{246}			C_{247}			C_{248}			Total		
C_{241}	1.00	1.00	1.00	2.50	3.17	3.82	1.20	1.59	1.89	0.83	1.00	1.20	0.83	1.00	1.31	1.44	2.24	2.96	1.00	1.26	1.57	0.83	1.26	1.89	9.64	12.53	15.64
C_{242}	0.26	0.31	0.40	1.00	1.00	1.00	0.41	0.50	0.69	0.24	0.31	0.48	0.27	0.33	0.44	0.58	0.71	1.00	0.31	0.40	0.58	0.36	0.44	0.58	3.42	4.00	5.18
C_{243}	0.53	0.63	0.83	1.44	2.00	2.47	1.00	1.00	1.00	0.48	0.63	1.00	0.53	0.63	0.83	1.00	1.41	1.73	0.69	0.79	1.00	0.55	0.83	1.10	6.23	7.93	9.97
C_{244}	0.83	1.00	1.20	2.08	3.17	4.22	1.00	1.59	2.08	1.00	1.00	1.00	0.83	1.00	1.20	1.20	2.24	3.27	1.00	1.26	1.44	0.76	1.26	1.89	8.71	12.53	16.29
C_{245}	0.76	1.00	1.20	2.26	3.03	3.71	1.20	1.59	1.89	0.83	1.00	1.20	1.00	1.00	1.00	1.31	2.14	2.88	1.00	1.26	1.44	0.87	1.32	1.73	9.24	12.34	15.05
C_{246}	0.34	0.45	0.69	1.00	1.41	1.73	0.58	0.71	1.00	0.31	0.45	0.83	0.35	0.47	0.76	1.00	1.00	1.00	0.44	0.56	0.83	0.52	0.62	0.70	4.53	5.66	7.56
C_{247}	0.64	0.79	1.00	1.73	2.52	3.22	1.00	1.26	1.44	0.69	0.79	1.00	0.69	0.79	1.00	1.20	1.78	2.26	1.00	1.00	1.00	0.60	1.05	1.59	7.56	9.99	12.52
C_{248}	0.53	0.79	1.20	1.71	2.29	2.76	0.91	1.20	1.81	0.53	0.79	1.31	0.58	0.76	1.15	1.42	1.62	1.91	0.63	0.95	1.66	1.00	1.00	1.00	7.31	9.41	12.80

SC_{241}=(0.10, 0.17, 0.28), SC_{242}=(0.04, 0.05, 0.09); SC_{243}=(0.07, 0.11, 0.18), SC_{244}=(0.09, 0.17, 0.29), SC_{245}=(0.10, 0.17, 0.27), SC_{246}=(0.05, 0.08, 0.13), SC_{247}=(0.08, 0.13, 0.22), SC_{248}=(0.08, 0.13, 0.23).

	C_{261}			C_{262}			Total		
C_{261}	1.00	1.00	1.00	0.60	0.66	0.76	1.60	1.66	1.76
C_{262}	1.31	1.51	1.66	1.00	1.00	1.00	2.31	2.51	2.66

SC_{261}=(0.36, 0.40, 0.45), SC_{262}=(0.52, 0.60, 0.68).

The I_T^{α} values and weights calculated for the sub-criteria and sub-sub criteria were given in Table 7 and Table 8, respectively.

Table 7. I_T^α Values and weights of sub-criteria

Criteria	I_T^α	W^T
C_{11}	0.434	0.422
C_{12}	0.282	0.274
C_{13}	0.313	0.304
C_{21}	0.228	0.220
C_{22}	0.204	0.197
C_{23}	0.185	0.178
C_{24}	0.204	0.197
C_{25}	0.097	0.094
C_{26}	0.117	0.113
C_{31}	0.475	0.474
C_{32}	0.527	0,526
C_{41}	0.345	0.345
C_{42}	0.312	0.311
C_{43}	0.345	0.345
C_{51}	0.335	0.333
C_{52}	0.337	0.335
C_{53}	0.335	0.333
C_{61}	0.176	0.175
C_{62}	0.176	0.175
C_{63}	0.176	0.175
C_{64}	0.163	0.162
C_{65}	0.101	0.100
C_{66}	0.074	0.073
C_{67}	0.141	0.140

Table 8. I_T^α Values and weights of sub-sub-criteria

Sub-sub criteria	I_T^α	W^T
C_{111}	0.365	0.360
C_{112}	0.325	0.320
C_{113}	0.325	0.320
C_{121}	0.250	0.250
C_{122}	0.250	0.250
C_{123}	0.250	0.250
C_{124}	0.250	0.250
C_{131}	0.411	0.381
C_{132}	0.255	0.237
C_{133}	0.156	0.145
C_{134}	0.255	0.237
C_{211}	0.205	0.201
C_{212}	0.132	0.130
C_{213}	0.146	0.144
C_{214}	0.172	0.170
C_{215}	0.131	0.129
C_{216}	0.065	0.064
C_{217}	0.078	0.077
C_{218}	0.086	0.085
C_{221}	0.429	0.425
C_{222}	0.429	0.425
C_{223}	0.151	0.149
C_{231}	0.378	0.378
C_{232}	0.346	0.345
C_{233}	0.278	0.277
C_{241}	0.179	0.167
C_{242}	0.059	0.055
C_{243}	0.114	0.106
C_{244}	0.179	0.168
C_{245}	0.174	0.163
C_{246}	0.083	0.078
C_{247}	0.142	0.133
C_{248}	0.139	0.130
C_{261}	0.402	0.401
C_{262}	0.602	0.599

After this step, the global weights were found by multiplying the local weights of all criteria with the local weights of their sub-criteria and sub-sub criteria. The obtained results are presented in Table 9.

Table 9. Global weight results of fuzzy total integral value method

Criteria	w	Sub-criteria	w	Sub-sub criteria	w	Global weight
C_1	0.192	C_{11}	0.422	C_{111}	0.360	0.029
				C_{112}	0.320	0.026
				C_{113}	0.320	0.026
		C_{12}	0.274	C_{121}	0.250	0.013
				C_{122}	0.250	0.013
				C_{123}	0.250	0.013
				C_{124}	0.250	0.013
		C_{13}	0.304	C_{131}	0.381	0.022
				C_{132}	0.237	0.014
				C_{133}	0.145	0.008
				C_{134}	0.237	0.014
C_2	0.157	C_{21}	0.220	C_{211}	0.201	0.007
				C_{212}	0.130	0.004
				C_{213}	0.144	0.005
				C_{214}	0.170	0.006
				C_{215}	0.129	0.004
				C_{216}	0.064	0.002
				C_{217}	0.077	0.003
				C_{218}	0.085	0.003
		C_{22}	0.197	C_{221}	0.425	0.013
				C_{222}	0.425	0.013
				C_{223}	0.149	0.005
		C_{23}	0.178	C_{231}	0.378	0.011
				C_{232}	0.345	0.010
				C_{233}	0,277	0.008
		C_{24}	0.197	C_{241}	0,167	0.005
				C_{242}	0.055	0.002
				C_{243}	0.106	0.003
				C_{244}	0.168	0.005
				C_{245}	0.163	0.005
				C_{246}	0.078	0.002
				C_{247}	0.133	0.004
				C_{248}	0.130	0.004
		C_{25}	0.094	C_{251}	1.000	0.015
		C_{26}	0.113	C_{261}	0.401	0.007
				C_{262}	0.599	0.011
C_3	0.067	C_{31}	0.474			0.032
		C_{32}	0.526			0.035
C_4	0.192	C_{41}	0.345			0.066
		C_{42}	0.311			0.060
		C_{43}	0.345			0.066
C_5	0.157	C_{51}	0.333			0.052
		C_{52}	0.335			0.053
		C_{53}	0.333			0.052
C_6	0.236	C_{61}	0.175			0.041
		C_{62}	0.175			0.041
		C_{63}	0.175			0.041
		C_{64}	0.162			0.038
		C_{65}	0.100			0.024
		C_{66}	0.073			0.017
		C_{67}	0.140			0.033

The Applicability Analysis Results

The applicability of the measures taken on board ships were found by calculating the average of the scores given by the experts to the measures in the hierarchical structure. The geometric mean method was used to determine the mean of expert opinions. The applicability analysis results are presented in Table 10.

Table 10. The applicability of the measures taken on board ships

Criteria	Applicability	Sub-criteria	Applicablity	Sub-Sub criteria	Applicability
C_1	4.1	C_{11}	2.9	C_{111}	2.9
				C_{112}	3.1
				C_{113}	3.1
		C_{12}	4.5	C_{121}	4.1
				C_{122}	4.1
				C_{123}	3.5
				C_{124}	3.0
		C_{13}	2.6	C_{131}	3.2
				C_{132}	3.1
				C_{133}	3.6
				C_{134}	2.8
C_2	3.6	C_{21}	4.3	C_{211}	4.6
				C_{212}	3.5
				C_{213}	4.1
				C_{214}	4.6
				C_{215}	3.1
				C_{216}	3.5
				C_{217}	1.5
				C_{218}	2.4
		C_{22}	3.8	C_{221}	4.6
				C_{222}	4.6
				C_{223}	3.9
		C_{23}	3.5	C_{231}	5.0
				C_{232}	4.8
				C_{233}	3.2
		C_{24}	3.3	C_{241}	3.6
				C_{242}	3.1
				C_{243}	3.4
				C_{244}	4.3
				C_{245}	4.2
				C_{246}	2.5
				C_{247}	3.8
				C_{248}	4.6
		C_{25}	4.8	C_{251}	3.3
		C_{26}	1.9	C_{261}	3.4
				C_{262}	3.7
C_3	5.0	C_{31}	5.0		
		C_{32}	4.8		
C_4	2.1	C_{41}	1.6		
		C_{42}	1.9		
		C_{43}	2.8		
C_5	5.0	C_{51}	4.6		
		C_{52}	5.0		
		C_{53}	4.8		
C_6	3.9	C_{61}	4.8		
		C_{62}	4.6		
		C_{63}	4.8		
		C_{64}	3.8		
		C_{65}	4.3		
		C_{66}	2.6		
		C_{67}	3.8		

According to the analysis results, the order of the main criteria was $C_6>C_1=C_4> C_2=C_5>C_3$. In the ranking made according to the importance of the measures to prevent the risk of coronavirus transmission, 'Getting Enough Sleep', 'Eating adequate/nutritious foods' and 'Exercise' measures were on the top two places. One of the most striking results of this study was that 'Getting Enough Sleep' and 'Exercise' measures were two of the three criteria with the lowest applicability value among all criteria. The imbalance between the work and rest hours of seafarers becomes apparent here as well. Seafarers' work and rest hours do not reflect reality and it is a real problem known to everyone in the maritime industry. This problem needs to be solved immediately. Baumler et.al. (2020) conducted a study on seafarers' rest hours. It was revealed that the working/rest hour records of all seafarers participating in the study were adjusted. The results of this paper also support the conclusions that Baumler et al. (2020) referred to regarding the imbalance in the working hours of seafarers. Violations during the rest hours due to commercial pressure lead to a departure from the culture of "safety first" and in this environment, which suggests that human health is not valued enough, "work first" culture takes its place. In order to solve this problem, it is thought that the regulations regarding the minimum number of seafarers employed on the ships should be reviewed and a new regulation should be made by investigating the balance of workload and rest hours.

Measures taken through training, measures to be applied in case of personnel showing disease symptoms, and temperature measurement were also at the top of the importance ranking. The applicability values of these measures were also high. In the *10th* and *11th* row of the efficiency ranking, there were measures related to maintaining physical distance at port. When these results were analyzed in terms of ship locations, it was revealed that it was more important to maintain physical distance on deck at the port. The applicability level of maintaining physical distance onboard during port operations was slightly below average. It is believed that observing the recommended working zones on the ship will reduce the risk during port operations. When the measures between the *12th* and *20th* places of the importance ranking were examined, it was seen that the measures with below-average applicability level were 'Washing the laundry of the personnel with disease symptoms by hand' and 'Maintaining physical distance in the engine room during the arrival/departure maneuver'. It is thought that the reason for the low applicability of hand washing the clothes of the person with symptoms of illness in the ship environment was that the cabin environment was not suitable, and the person may not have the body strength to do this. In the engine control room, which is a closed environment, it was deduced that because of the possibility of violations in maintaining the physical distancing due to the need to work punctually as a team, the applicability of 'Maintaining physical distancing in the engine room during arrival/departure' was considered to be low. When the measures between the *27th* and the last place of the ranking were examined, the measures that had the lowest level of applicability were 'Use of disposable overalls-masks-gloves-visors by the personnel working on the deck at the risky port', 'Using separate overalls-shoes at the port and in the accommodation', and 'Making sure visitors from the port are wearing overshoes'. It was concluded that the applicability levels were low because it would not be easy to change overalls and shoes in such a busy working environment. It is thought that the reason for the low applicability of the measure of making sure visitors arriving at the accommodation are wearing overshoes was that it was not known whether the overshoe could reduce the safety in a dangerous working environment where safety shoes are worn and whether visitors would pay attention to the use of overshoes.

Conclusion

In the face of the global pandemic of the COVID-19, shipping has continued at the cost of seafarers' health and safety. There are some studies (Baygi et al., 2021; Lucas et al., 2021; Luchenko and Georgiievskyi, 2021; Pauksztat et al., 2022) on the impact of the ongoing pandemic on seafarers' health and well-being. Unlike these studies, this paper focused on the importance and applicability of the safety measures taken against COVID-19 to reduce the risk of contamination on board the ships. Fuzzy AHP with total integral value with optimism index and a five-point Likert scale was used for calculation. The quantitative analysis showed that immune system protective measures were the most important measures; however, two of them have the lowest applicability value among all criteria. The present work has explored the imbalance in rest and working hours of seafarers. When analyzing the ship locations and operations, maintaining physical distance on deck at port was found more important. Its applicability level was slightly below average.

The findings of this study will be of great interest to maritime policymakers, all kinds of shipping companies, seafarers, and researchers. This research is a resource that shipping companies can use in the risk assessment process and during the procedure development phase. The study will create awareness in the maritime sector and contribute to the protection of seafarers' health and safety, thus increasing the overall quality of the maritime industry.

In future studies, the results of this study can be expanded by using different multi-criteria decision-making methods and by conducting a study to reveal the safety climate during the COVID-19 pandemic with the participation of crew members at all levels.

Compliance with Ethical Standard

Conflict of interests: The authors declare that for this article they have no actual, potential or perceived conflict of interests.

Ethics committee approval: The current study had been approved by the Social Sciences and Humanities Ethics Committee of Istanbul Technical University.

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