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Mapping Mental Health of Seafarers Post-COVID-19: A Gaussian Graphical Model of Depression, Anxiety, and Maritime Working Conditions

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Abstract

This cross-sectional study examines the levels of depression and anxiety experienced by seafarers working in countries bordering the Black Sea in the post-COVID-19 period; it also evaluates the effects of these mental conditions on socio-demographic variables, problems encountered in ship and port environments during the pandemic, and career planning. Analyzes were conducted using the Beck Depression Inventory-II (BDI-II) and Generalized Anxiety Disorder-7 (GAD-7) scales. Additionally, a Gaussian Graphical Model (GGM) was used to analyze the interaction between psychological outcomes and working conditions and career planning. Findings reveal that, compared to pre-pandemic levels, depression and anxiety levels remain high. According to the results, 38.8% of participants show signs of depression, and 56.7% exhibit symptoms of anxiety. Anxiety levels are higher among officers and those with less maritime experience. GGM analysis shows that while the direct effects of COVID-19 have diminished, interactions between shipboard and port-related challenges persist. Strong relationships were observed between stressful working conditions on board, excessive alcohol consumption, and pressure from superiors. Port-related issues such as feeling isolated at port and pressure from port authorities emerged as key bridging variables in the network. Ship-related issues have a greater impact on seafarers' well-being in the working conditions compared to port-related issues; however, port-related issues should also be addressed through appropriate interventions. A weak association was also found between the intention to discontinue working on board and the level of anxiety. Based on these findings, it is recommended to systematically address workplace tension due to work pressure, implement onboard psychological monitoring, provide targeted support for junior officers, integrate mental health training in maritime academies, improve leadership and workload balance, and include psychosocial indicators in post-contract evaluations.

Keywords

depression, anxiety, Gaussian graphical model, post COVID-19, seafarer, working condition

Highlights

- This study reveals that seafarers' depression and anxiety levels remained high in the post-Covid-19 period.
- GGM shows ship-related factors strongly affect mental health; port-related stressors worsen it indirectly.
- Findings call for holistic policies addressing both ship and port factors.

Introduction

The COVID-19 pandemic, first reported in late 2019, caused major disruptions in all areas of life on a global scale, and the maritime industry was significantly affected.[1,2] Measures such as travel restrictions, quarantine protocols, and limitations on crew changes led to substantial changes in seafarers' daily lives and work routines.[3,4] During this period, prolonged isolation, uncertainty, and contract extensions became widespread, posing serious risks to mental health.[5] Mental

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health is defined not merely as the absence of mental illness, but as a broader state of well-being that includes an individual's ability to cope with stress and fulfill social and functional roles.[6,7] Common mental health conditions such as depression, anxiety, and stress are shaped by a wide range of individual, social, and environmental factors.[8-11] Therefore, assessing the mental health of seafarers requires not only focusing on clinical symptoms but also addressing the social and environmental dimensions of their working conditions. Moreover, the mental health of seafarers is a critical issue not only in terms of individual well-being but also for the safety of maritime operations. Human error remains one of the leading causes of marine accidents, and seafarers experiencing psychological distress may suffer impairments in attention, decision-making, and crisis management skills.[12,13]

To better understand the psychological impact of COVID-19 on seafarers, it is important to also consider the pre-pandemic context. Research conducted before the pandemic revealed that seafarers already experienced higher levels of depression (10%-37%) and anxiety (17%-30%) compared to the general population.[14-16] For instance, Lefkowitz and Slade[15] reported that 25% of international seafarers exhibited symptoms of depression, 17% showed signs of anxiety, and 20% reported suicidal ideation. Zamora et al.[16] found that prolonged exposure to social media was associated with depression and anxiety, particularly among less experienced seafarers. Similarly, Andruskiene et al.[14] reported that poor sleep quality was a significant predictor of psychological symptoms among maritime students. These findings suggest that even before the pandemic, seafarers represented a vulnerable group in terms of mental health due to the unique challenges of their profession.

Studies conducted since the onset of the pandemic have shown that seafarers, as essential workers responsible for approximately 80% of global trade, have been operating under extreme stress and pressure.[17,18] Challenges such as lack of shore leave, limited communication with families, fear of infection, and increased workloads have led to significant rises in depression, anxiety, and stress among seafarers.[19,20] According to the International Seafarers' Welfare and Assistance Network (ISWAN), calls for help involving suicidal thoughts doubled during the pandemic, while overall helpline contacts tripled compared to pre-pandemic levels.[21] Even in the following year, issues such as stress, anxiety, and isolation remained the most frequently reported mental health concerns among seafarers.[22] Data from the Seafarers Happiness Index for the same period also indicated a significant decline in seafarers' happiness levels in the first quarter of 2022.[23]

During the pandemic, this vulnerability deepened further. Several studies reported that over 40% of seafarers exhibited symptoms of depression, and more than 50% showed signs of anxiety.[24-27] Country-specific research has revealed that mental health problems among seafarers have become widespread, associated with factors such as sleep disturbances, financial difficulties, contract extensions, separation from family, and social isolation on board.[28-32] Coping strategies including social support, efforts to maintain positivity, and communication among crew members have emerged as key factors supporting psychological well-being. Large-scale data confirm that strong safety culture and clear employer communication during crises have protective effects on seafarers' mental health.[33]

Findings increasingly indicate that the negative impacts of COVID-19 on seafarers' mental health have persisted immediately after the pandemic. Svetina et al.[34] and Zhao et al.[35] emphasized that stress, anxiety, and isolation among seafarers did not decrease in the post-pandemic period, and the need for psychological support continued. This situation is related not only to the traumas experienced during the pandemic but also to the persistence of structural issues within the industry.[36,37] The findings suggest that mental health support should not be limited to crisis periods but transformed into long-term strategies.

This study aims to examine whether the stressors faced by seafarers during the COVID-19 pandemic continue to affect their psychological well-being in the post-pandemic period. Focusing on seafarers from Black Sea countries, the study assesses depression and anxiety levels in relation to sociodemographic factors, ship and port related issues, and career planning. A Gaussian Graphical Model (GGM) approach is used to uncover how these variables interact within a network structure and to identify potential targets for intervention. This regional perspective contributes to the growing body of research on seafarers' mental health and provides insights for both national and international maritime policy.

Literature Review

During the COVID-19 pandemic, numerous studies highlighted the serious mental health challenges faced by seafarers, emphasizing the psychological burden caused by prolonged isolation, contract extensions, and limited access to support systems. Baygi et al.[38] found a 44.8% prevalence of psychosocial distress and significant associations between time spent on board and levels of depression and stress. Also, in a study by Baygi et al.,[26] conducted with 439 multinational seafarers working on international ships, 14.1% of the participants exhibited depressive symptoms and 12.4% reported anxiety symptoms. The study also found that longer service duration onboard was associated with a higher risk of depression and intrusion symptoms, while officers showed significantly higher levels of anxiety and depression than non-officers. Qin et al.[25] in a study conducted with 441 seafarers in China during the pandemic, found that 40.12% of participants exhibited depression symptoms using the Self-Rating Depression Scale (SDS). The negative effects of extended time on ships were associated with reduced exercise time and poor sleep quality. Pauksztat et al.[39] conducted a large-scale international study involving seafarers from over 40 countries and concluded that pandemic-specific stressors such as extended duty periods and increased working hours were significantly associated with symptoms of anxiety and depression. However, the presence of peer support and internet access appeared to buffer some of these effects. In a large-scale study including over 17 000 seafarers, Hayes-Mejia and Stafström[33] found that delays in crew changes and unclear communication

by employers during the pandemic had a negative impact on seafarers' mental health, while strong safety culture and clear crisis communication were associated with better psychological outcomes.

Numerous studies conducted during the pandemic have emphasized stress as a key factor affecting seafarers' mental health.[10,23,40] The existing literature reveals that factors such as the nature of the job itself, company policies, planning activities, and the lack of socialization opportunities were responsible for the increased stress levels among seafarers during the pandemic.[23] Regional studies conducted in Thailand, India, China, Turkey, and the Philippines have demonstrated elevated levels of depression, anxiety, and stress among seafarers throughout the pandemic.[28-32,41] These adverse mental health outcomes have been linked to factors such as sleep disturbances, financial difficulties, contract uncertainties, and separation from family. On the other hand, coping strategies including social support, positive thinking efforts, and effective communication have been found to support seafarers' psychological well-being. Large-scale studies confirm that a safe working environment and clear, transparent employer communication during crisis periods have protective effects on seafarers' mental health.

Despite the overwhelming evidence of COVID-19′s psychological toll on seafarers, concerns remain that the pandemic's shadow continues to loom over their mental well-being in the post-COVID-19 era. In a recent study, Svetina et al.[34] examined seafarers' mental health across 12 countries and identified 3 groups of stressors associated with adverse mental health outcomes: Environmental conditions (eg, vibration), social factors (eg, bullying, homesickness, working alone), and health-related problems (eg, physical injuries and illness). The study also found that both stress exposure and psychological symptoms were linked to seafarers' motivation and their considerations about leaving the maritime profession. In a post-COVID-19 study conducted by Sharma,[42] the mental health of 109 Indian seafarers was assessed between March and April 2023. The findings revealed mild levels of depression (Mean = 13.54), moderate anxiety (Mean = 10.81), and moderate burnout, with average disengagement and exhaustion scores of 20.03 and 20.43, respectively. A moderate positive correlation was observed between depression, anxiety, stress, and burnout scores, highlighting the ongoing psychological burden among seafarers in the aftermath of the pandemic. In a post-COVID-19 comparative study, Zhao et al.[35] found that seafarers reported even higher levels of fatigue after the pandemic than during it. Although initially unexpected, in-depth interviews revealed that increased regulatory inspections and updated shipboard protocols following the pandemic significantly intensified the workload. In a post-pandemic cross-sectional study, Strukcinskiene et al.[43] identified key occupational stressors among Lithuanian seafarers, including workplace changes, interpersonal relationships, lack of peer support, and insufficient management backing. The study further revealed that junior seafarers and those with fewer years of service reported significantly higher stress levels, emphasizing the need for tailored stress management interventions across varying experience levels. These findings underscore the need for effective fatigue risk management practices to safeguard the well-being of seafarers in the evolving regulatory landscape.

A comprehensive compilation of studies focusing on the mental health of seafarers during and after the COVID-19 period is presented in Table 1, classified according to the data collection timeframe of each study. As shown in Table 1, while numerous studies have explored the mental health of seafarers during the COVID-19 period, research focusing on the post-pandemic context remains considerably limited. This study aims to evaluate whether the challenges faced by seafarers during the COVID-19 pandemic continue to have an impact on their mental health even in the post-COVID-19 period. Factors such as the isolation and complex interpersonal relationships associated with working in a maritime environment, difficulties encountered during port operations, and uncertainties in career planning have been identified and analyzed based on the seafarers' own accounts. In this context, the main question of the study is whether the issues caused by COVID-19 have temporary, long-term, or chronic effects. If these issues prove to be chronic, the study aims to propose solutions to eliminate them. In the literature, it is observed that most mental health research of this nature is limited to traditional statistical analyses. However, in this study, to reveal the complex relationships between key mental health indicators such as depression and anxiety and the issues faced, a comprehensive network analysis model was applied, going beyond traditional methods. In this study, the GGM method was employed, which is rarely used in maritime research. Unlike linear regression and structural equation modeling approaches, GGM presents the conditional dependencies among variables in a multivariate structure through a network format. This method allows for a more holistic and interactive analysis of systemic stress factors in shipboard life. In this respect, the study offers an innovative contribution to the maritime mental health literature, both analytically and visually. Network analysis offers an innovative approach for visualizing the interrelationships between variables and assessing potential causalities. Moreover, by focusing on seafarers working in countries bordering the Black Sea, the study not only provides a regional mental health profile but also allows for comparisons of these findings with the global maritime sector. In this way, it contributes to understanding region-specific psychosocial dynamics and creates a scientific foundation for industry intervention strategies.

Materials and Methods

In this study, the depression and anxiety levels of seafarers from countries bordering the Black Sea in the post-COVID-19 period were assessed, and the relationships between their

Table 1. Studies on the Mental Health of Seafarers.

Author/s	Key variables analyzed in the study	Research design and scales used (if any)	Data analysis methods employed	Timeframe of previous studies' data gathering	
				During COVID-19 only (March 2020–April 2022)	After COVID-19 only (April 2022 onward)
Tang et al.[44]	Supports, perceived usefulness	Mixed methods; quantitative and qualitative	Descriptive statistics	X	
Carrera-Arce et al.[45]	Mental health as a part of general health, impact of COVID-19 on seafarer's mental health and wellbeing	Mixed methods; quantitative and qualitative	Pearson chi-square	X	
Hayes-Mejia and Stafström[33]	Stress, anxiety, depression; crew change policy; psychosocial work environment; safety communication	Cross-sectional; Perceived Stress Scale (PSS), Generalized Anxiety Disorder (GAD), Patient Health Questionnaire (PHQ)	Binary linear regression; multivariate linear regression	X	
Slišković[46]	Mental well-being, physical well-being, social well-being, economic well-being	Qualitative descriptive study	Thematic analysis	X	
Nittari et al.[11]	Mental health, fatigue, stress, social isolation, long work shifts, suicide	Systematic literature review	Literature review	X	
Wong[30]	Anxiety, repatriation expectation, negative work performance	Literature review and quantitative	Literature review, correlation analysis	X	
Onakpojeruo et al.[47]	Depression, fatigue, communication, sleep deprivation	Modified Human Error Assessment and Reduction Technique (HEART) methodology; EIF weighting through expert seafarer questionnaire	HEART-based Human Error Probability (HEP) calculation, Event Tree Analysis (ETA)	X	
Brooks and Greenberg[48]	Age, marital status, physical health, noise, safety, workload, hours, sleep, support, autonomy	Systematic review	Thematic synthesis of qualitative and quantitative analysis	X	
Erdem and Tutar[31]	COVID-19 anxiety, burnout, intention to quit, work stress	Cross-sectional; COVID-19 anxiety scale, COVID-19 burnout scale, intention to leave scale, job stress scale	Structural Equation Model (SEM)	X	
Jonglertmontree et al.[28]	Depression, sleep problems, coping behavior, safety behavior, repetitive tasks	Cross-sectional; PHQ-9, Carver Brief Cope Inventory	Chi-square, multivariate logistic regression	X	
Zhao et al.[49]	Fatigue, personal protective equipment use, fear of infection, shore leave deprivation, service time	Mixed methods; quantitative and qualitative	Weighted mean fatigue scores, thematic analysis	X	
Timilsina and Baygi[50]	Seafarers' health and wellbeing, repatriation delay, stress, anxiety	Qualitative study	Inductive coding	X	
López López et al.[51]	Fatigue, stress, anxiety, depression, psychiatric disorders, crew change difficulties, quarantine, medical service access	Regulatory review and qualitative assessment	Review	X	
Coutroubis et al.[52]	Physical wellbeing, mental wellbeing, economic wellbeing	Quantitative survey	Descriptive statistical analysis	X	
Kaur and Joy[29]	Depression, anxiety, stress	Cross-sectional; Depression Anxiety Stress Scales-21 (DASS-21)	Chi-square	X	
Maşalacı[53]	Seafarers' mental health, wellbeing	Bibliometric analysis	VOSviewer	X	
Abila and Malecosio[54]	Mental Health and Psychosocial Support (MHPSS)	Cross-sectional; mental health and psychosocial support	Descriptive analysis	X	

(continued)

Table 1. (continued)

Author/s	Key variables analyzed in the study	Research design and scales used (if any)	Data analysis methods employed	Timeframe of previous studies' data gathering	
				During COVID-19 only (March 2020–April 2022)	After COVID-19 only (April 2022 onward)
Sarinas et al.[55]	Stress and fatigue	Descriptive survey	Descriptive analysis	X	
Nguyen et al.[56]	Uncertainty, self-concern, living conditions, job satisfaction	Qualitative study	Thematic analysis	X	
Vairavan[57]	Mental health, physical health, fatigue, restlessness	Narrative/Descriptive review	Qualitative analysis	X	
Şenbursa et al.[58]	Mental health, physical health	Cross-sectional; World Health Organization recommendations for health interview surveys (SF-36)	Chi-square tests, multivariate logistic regression	X	
Baygi et al.[38]	Depression, anxiety, stress, self-rated anxiety, general psychiatric disorders, and poor perceived health status	Cross-sectional; DASS-21, General Health Questionnaire-12 (GHQ-12), Zung Self-Rating Anxiety Scale (SAS)	Multivariate logistic regression	X	
Baygi et al.[26]	Depression, anxiety, posttraumatic stress	Cross-sectional; GAD-7, Posttraumatic Stress Disorder (PTSD8), PHQ-9	Multivariate logistic regression	X	
Pauksztat et al.[39]	Mental health problems, fatigue	Cross-sectional; Patient Health Questionnaire-4 (PHQ-4), seafarers' fatigue scale	SEM	X	
Qin et al.[25]	Depression, stress	Cross-sectional; Zung Self-Rating Depression Scale (SDS)	Logistic regression	X	
Svetina et al.[34]	Depression, anxiety, hostility, interpersonal sensitivity, somatisation	Cross-sectional; The Symptom Checklist (SCL-90)	Regression analyzes		X
Sharma[42]	Depression, anxiety, burnout	Cross-sectional; Depression Anxiety and Stress Scale-42 (DASS-42), Oldenburg burnout inventory	Independent sample Kruskal Wallis test and Whitney U test, correlational analysis		X
Zhao et al.[35]	Fatigue	Mixed methods; quantitative and qualitative; Cardiff Seafarers' Fatigue Research Program	Comparative analysis; thematic analysis		X
Senbursa and Dunder[59]	Psychological well-being (PW), loneliness at work (LAW), psychological resilience (PR)	Cross-sectional; psychological well-being scale, loneliness at work scale, psychological resilience scale	SEM		X
Strukcinskiene et al.[43]	Occupational stressors among seafarers	Cross-sectional; HSE Management Standards Indicator Tool (HSE-MSIT)	Kolmogorov–Smirnov, Friedman, Mann–Whitney U, and Spearman's correlation analysis		X

mental health and socio-demographic characteristics were analyzed. The depression levels of seafarers were assessed using the Beck Depression Inventory-II (BDI-II), while their anxiety levels were evaluated using the Generalized Anxiety Disorder-7 (GAD-7) scale. Furthermore, the connections between their mental health and the issues identified through interviews under the themes of ship-related issues, port-related issues, and career planning were examined using the innovative method of the GGM. A comprehensive workflow diagram of the study is presented in Figure 1.

Sample Size, Study Design and Period

For sample size analysis, the population of seafarers from the Black Sea region was first estimated. According to the 2021 Seafarer Workforce Report, there are 198 123 Russian and 76 442 Ukrainian seafarers globally.[60] The 2019 data from the Turkish Ministry of Transport and Infrastructure reports 101 277 active Turkish seafarers.[61] Although no exact data are available for Georgia, Romania, and Bulgaria, based on Russia's global share of 10.5%,[60] the total number of seafarers from these countries was estimated at 100 000. Thus, the study population was approximated as 475 000.

In calculating the required sample, population proportion was also considered.[62] This refers to the percentage of individuals with specific characteristics and is key in medical sample estimations.[63] Depression and anxiety prevalence among seafarers is estimated at 20%.[15,64] Based on this, the minimum sample was calculated as 246 (95% CI, 5% margin).

Data were collected from 368 seafarers in Türkiye, Romania, Bulgaria, Ukraine, Russia, and Georgia. After excluding 13 ineligible participants, data from 355 individuals were analyzed exceeding the required sample by 40%.

In this study, a cross-sectional study design was chosen for use. A cross-sectional study allows for inferences about trends, attitudes, and opinions regarding the broader population based on the perspectives of a sample group selected from a specific population.[65] In the study conducted within this design, a survey method was used as the data collection tool. The surveys were conducted with participants using 2 different methods: Online and face-to-face. In accordance with the scope and methods of the study, participants were selected from individuals who were either currently working on ships or had recently signed off from vessels. The data for the research were collected between April 2022 and November 2022, a period that can be defined as the post-COVID-19 phase. In addition, this study followed the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for cross-sectional studies.[66]

Scales

Beck Depression Inventory-II. In this study, BDI-II was used to assess depression levels. The beck depression inventory scale was initially developed by Beck and colleagues in 1961 to measure individuals' depression symptoms. After undergoing several revisions, the scale was updated in 1996 by Beck and colleagues, and following validity and reliability analyses, it was transformed into the 21-item BDI-II form. The BDI-II demonstrated excellent internal consistency (Cronbach's $\alpha = .91$), strong test-retest reliability ($r = .93$), and solid convergent validity with established depression and anxiety measures (eg, $r = .71$ with the Hamilton depression scale), supporting its reliability and construct validity for clinical use.[67-69] The method, in which each question is rated by participants on a scale from 0 to 3, assesses individuals' depression levels across 4 stages: Minimal, mild, moderate and severe depression, based on the total score obtained. Participants with total scores between 0 and 13 are classified as having minimal, scores between 14 and 19 as very mild, scores between 20 and 28 as moderate and scores between 29 and 63 as severe depression.[68,70] In the present study, the Cronbach's alpha coefficient for the BDI-II scale was found to be .91. The Kaiser-Meyer-Olkin (KMO) value was 0.93, and the results of Bartlett's test of sphericity were observed to be $\chi^2 = 2625.537$; $P < .001$.

Generalized Anxiety Disorder-7. In this study, GAD-7 scale was used to measure participants' anxiety levels. Developed in 2006 by Spitzer et al, the GAD-7 is a psychometric scale designed to assess and rate individuals' levels of anxiety.[71] The scale underwent rigorous validity and reliability analyses to ensure its measurement accuracy and consistency. The GAD-7 demonstrated excellent internal consistency (Cronbach's $\alpha = .92$), strong test-retest reliability (ICC = 0.83), high criterion validity (AUC = 0.906), and solid construct validity through significant correlations with functional impairment and other anxiety measures. The GAD-7 consists of a total of 7 questions that evaluate the participants' anxiety symptoms.[71,72] Participants rate how frequently they have experienced anxiety-related symptoms in the past 2 weeks, with a scale ranging from 0 "Not at all" to 3 "Nearly every day." The results are classified into 4 categories based on the total score, with anxiety levels ranging from minimal to severe. Individuals scoring between 0 and 4 are considered to have minimal, those with scores between 5 and 9 are classified as having very mild, those scoring between 10 and 14 have moderate and those with scores between 15 and 21 are considered to have severe anxiety symptoms.[71,73,74] In the present study, the Cronbach's alpha coefficient for the GAD-7 scale was found to be .87. The KMO value was 0.88, and the results of Bartlett's test of sphericity were observed to be $\chi^2 = 989.198$; $P < .001$.

Working Condition and Demographic Structure

A demographic structure questionnaire consisting of 7 questions was created to collect demographic data from seafarers. These socio-demographic variables were selected from

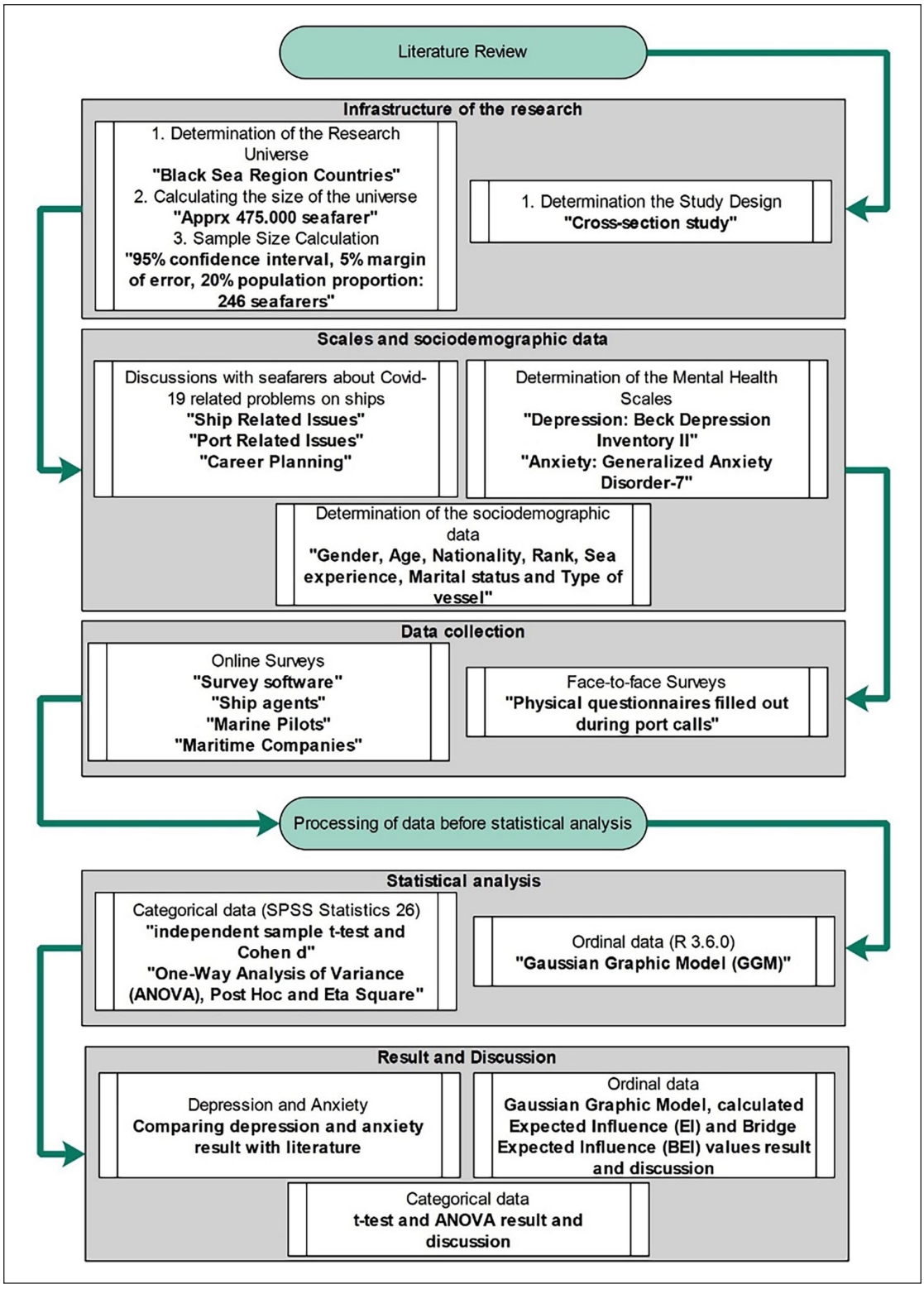


Figure 1. Workflow diagram of the study.

those frequently discussed in the literature, with their effects on individuals' mental health being addressed in various studies. In addition, various statements were formulated to assess whether the professional issues encountered by seafarers during their time on board during the COVID-19 period continue to have an impact on depression and anxiety

levels in the post-COVID-19 period. The statements were identified through face-to-face and online interviews conducted with seafarers working on ships during the COVID-19 period. The identified statements were grouped under 3 main themes: ship-related issues, port-related issues and career planning. The section consists of a total of 13 statements, including 5-point Likert scale items (SRI1-6, PRI1-4, and CP1) and multiple-choice items (PRI5 and PRI6). The study received approval from the relevant ethics committee. Participants were informed that the study had received ethics approval, and informed consent was obtained from all participants. To minimize potential response bias, participants were informed at the beginning of the survey that all responses would remain anonymous and would be used strictly for scientific research purposes. They were encouraged to respond sincerely to ensure the reliability and integrity of the findings.

Statistical Analysis

Examination of the Relationships Between Socio-Demographic Data and Depression and Anxiety. The relationships between socio-demographic data (categorical variables) and the levels of depression and anxiety among seafarers were analyzed using the IBM SPSS 26 statistical software.[75] To examine significant differences between 2 distinct groups within the scale, an independent samples t-test was applied. While the t-test analyzes the differences between the groups, Cohen's effect size (*d*) was calculated to measure the magnitude of this difference. A Cohen's *d* coefficient of .20 indicates a small effect size, .50 indicates a medium effect size, and .80 indicates a large effect size.[76-78]

One-Way Analysis of Variance (ANOVA) was used to examine the differences among 3 or more groups within the scale. ANOVA identifies the differences between groups; however, Post Hoc tests are applied to determine which specific groups show significant differences.[79,80] In this study, since it was determined that the groups were homogeneously distributed but their frequency distributions were not equal, Hochberg's GT2 analysis was preferred.[81] Following the ANOVA analyses, effect size was assessed using Eta Squared analysis. Eta Squared can be defined as the proportion of variance associated with each interaction and error, or explained by them.[82] Eta Squared values range from 0 to 1, where values close to 0.01 indicate a small effect size, values close to 0.06 indicate a medium effect size, and values close to or greater than 0.14 indicate a large effect size.[76,83]

Gaussian Graphical Model. The relationships between occupational difficulties and depression and anxiety variables were examined using the GGM. The GGM network structure was created using the R programing language (versions 3.6.0 and later) and RStudio Version 2024.12.0+467.[84]

GGM is an undirected graphical model commonly used for multivariate normal distribution-based scenarios. This model constructs the network structure based on conditional independence relationships between variables under the assumption of normality.[85,86] Unlike directed graphical models such as Bayesian networks, GGM generates undirected networks.[87] This characteristic makes it preferred in psychological and biological research, where no single node independently influences the entire system, and there are no independent nodes in the outcome. Statistically, undirected edges in GGM represent conditional independence relationships. The absence of an edge between 2 nodes indicates that these nodes are conditionally independent given other variables.[88] The network structure of GGM is constructed by leveraging patterns from the correlation matrices between variables.[87,89] GGM has been used in various fields of literature to assess individuals' mental states.[90-93] However, this study represents the first application of the GGM model on the well-being of seafarers. In this regard, it will make a significant contribution to the literature on seafarers' well-being as an introduction to the model.

In the analysis of the data, skewness and kurtosis coefficients were examined to assess the normal distribution. If the skewness and kurtosis coefficients fall between −2 and +2, the variables are considered to follow a normal distribution.[94] The skewness and kurtosis values for the variables are presented in Figure 2.

It is recommended to use regularized estimators for network structures created with small sample groups.[95] One of the most used models among regularized estimators is the Extended Bayesian Information Criterion with graphical Lasso (EBICglasso) approach. EBICglasso, developed by Chen and Chen, is a method used to control model complexity and identify significant variables.[96] By applying penalty parameters, this method removes unnecessary connections, thereby enhancing the interpretability of the network. In this study, the GGM network structure was constructed using the EBICglasso method.

The qgraph package was used for visualizing the network structure, and the variables were categorized into 5 thematic groups: Depression, anxiety, ship-related issues, port-related issues, and career planning. The qgraph package for R visualizes data through network models, where variables are nodes and correlations are edges, with edge width representing the strength of correlations.[97] To assess the significant connections within the network, node centrality (Expected Influence, EI) and the identification of critical inter-group connections were calculated using the Bridge Expected Influence (BEI) measurements with the help of the network tools package.[98] The EI value represents the measure used to determine the most influential node within the network, and it is calculated as the sum of all edges connected to the node.[99] The BEI value, on the other hand, is a metric used to identify nodes that may serve as bridges between groups within the network, calculated by summing the absolute weights of the edges between a node and other nodes across groups.[100]

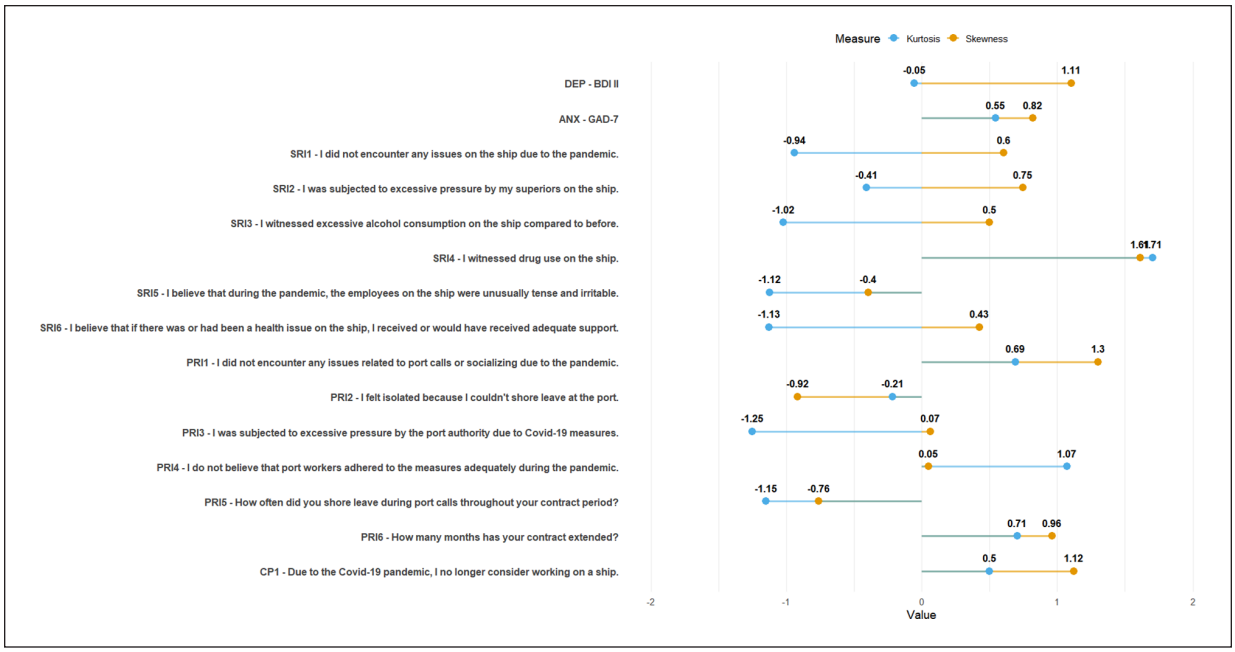


Figure 2. GGM nodes skewness and kurtosis coefficients.

Different analyses based on the bootstrapping method were used to assess network stability. Bootstrapping is a resampling technique that evaluates the reliability of statistical estimates by repeatedly drawing random subsamples.[101] In this study, widely accepted methods were employed to test network accuracy and stability. First, bootstrap edge weight accuracy analysis was performed using the bootnet package to visualize the confidence intervals and assess the reliability of edge weights.[102] Additionally, bootstrapped difference tests were applied to examine statistically significant differences in node strengths and edge weights.[103] The edge weight accuracy analysis revealed wide confidence intervals for several edges, indicating that low-weight edges should be interpreted with caution and validated by future studies (Figure 3). In this figure, each line represents a specific edge ordered by weight; red lines show original sample values, gray areas show confidence intervals, and black dots indicate the bootstrapped means. These plots are auto-generated by standard packages (bootnet and qgraph) and follow conventions established in the literature. Rather than focusing on axes, the width of the gray areas provides a visual cue for edge weight reliability, as suggested by Epskamp et al.[103] The bootstrapped difference tests also showed that nodes with higher centrality values were significantly different from others (Figure 4). In the plot, gray boxes denote non-significant differences, black boxes indicate significant ones, and white boxes with values display the strength centrality of each node.

To assess the stability of centrality measures, a case-dropping subset bootstrap analysis was conducted, and the correlation stability coefficient (CS-coefficient) was calculated. This coefficient reflects how reliable node centrality estimates are under sampling variability. Values above 0.25 (preferably >0.50) indicate acceptable stability.[103] In this study, the CS-coefficient was 0.400, suggesting moderate stability while underlining the need for future validation with larger samples. Figure 5 displays the average correlations between centrality indices from subset samples and the original network. The shaded areas represent 95% confidence intervals, ranging from the 2.5th to the 97.5th percentiles of these correlations.

Results

This section of the study presents the findings related to the sociodemographic characteristics of the participants, descriptive statistics on depression and anxiety levels, and the key relationships identified through GGM analysis. A total of 355 seafarers participated in the study. The majority of the participants were male (92.7%), while 7.3% were female. Regarding age, 53.5% were between 18 and 30 years old, and 46.5% were 31 years or older. In terms of nationality, 62.3% were from Türkiye and 37.7% were from other Black Sea countries. When categorized by rank, 30.2% were deck officers, 23.6% were cadets, 12.0% were masters, 11.1% were deck crew, 9.1% were engineers, 7.7% were chief engineers, and 6.3% were engine crew (Table 2).

When examining the relationship between the sociodemographic characteristics of seafarers and their levels of depression and anxiety, no significant relationship was found between depression levels, while a moderate, statistically significant relationship was observed between anxiety levels

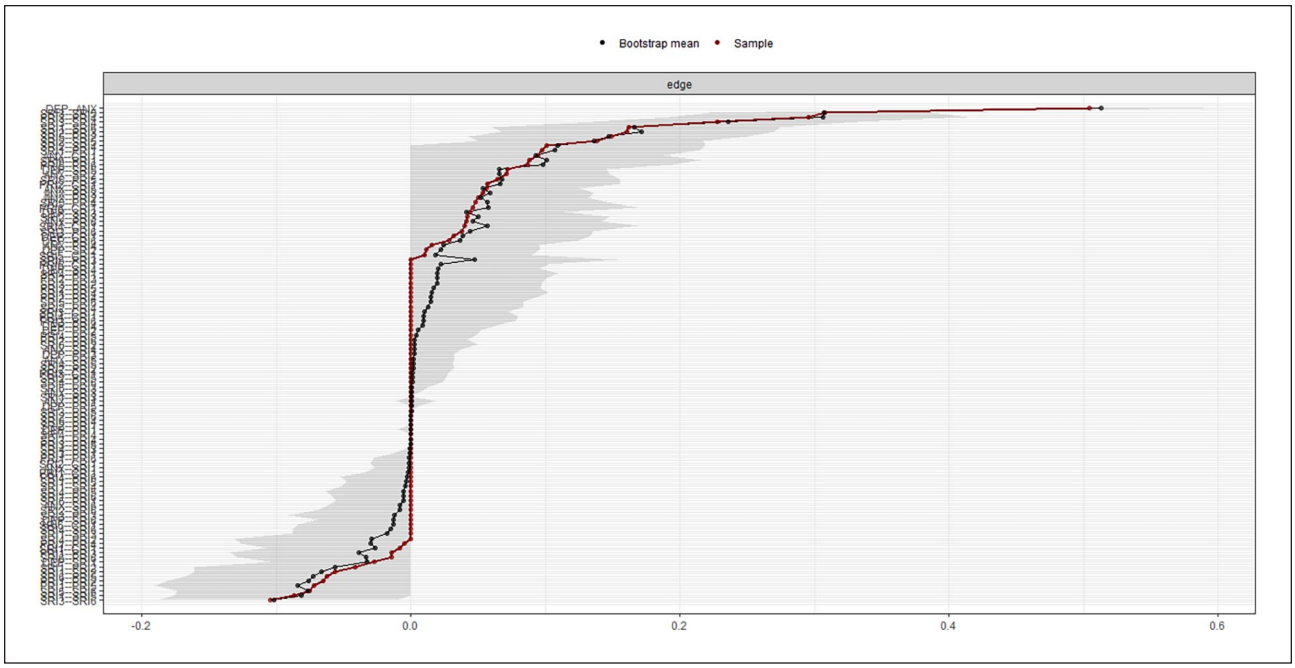


Figure 3. Bootstrap edge weight accuracy analysis.

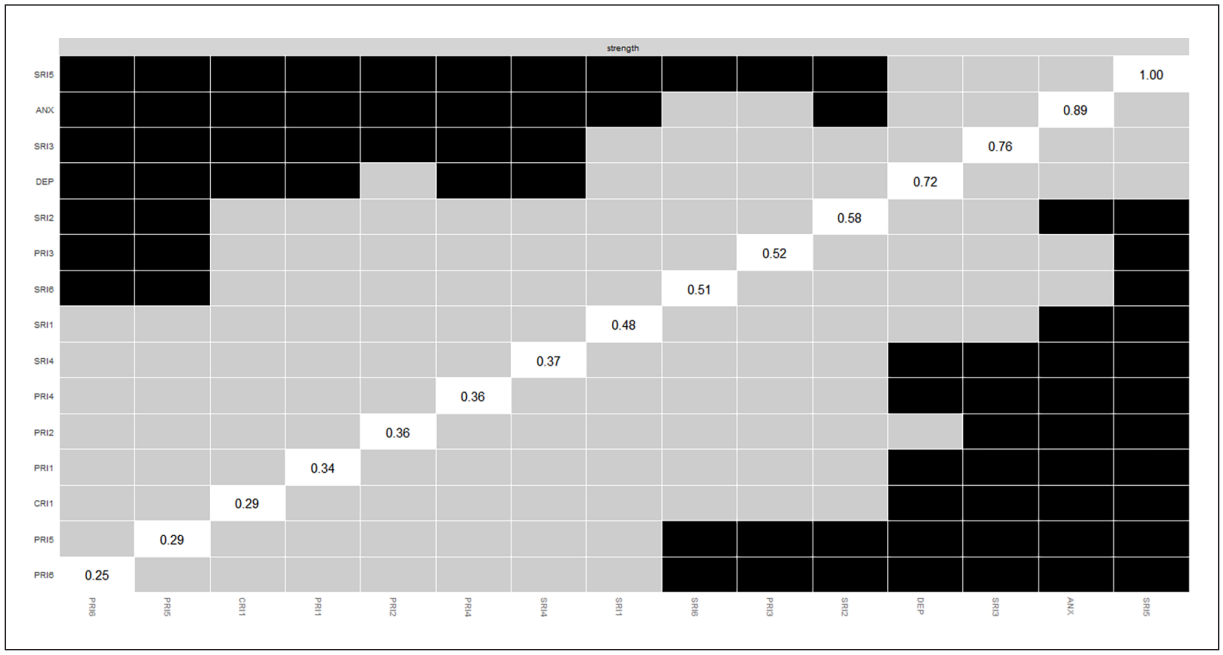


Figure 4. Bootstrapped difference tests.

and the rank and sea experience (Table 2). In Table 2, the t-value and ANOVA F-value indicate between-group differences, with P-values $< .05$ considered statistically significant.[104] Effect sizes are interpreted using Cohen's d and eta squared (η^2), as described in the "Materials and Methods" section. A statistically significant relationship was observed between anxiety levels and 4 socio-demographic variables: Age, nationality, rank, and sea experience. Seafarers aged 18 to 30 reported significantly higher anxiety levels compared to those aged 31 and above ($t = 2.282$, df = 339.8, $P = .023$), with a small effect size (Cohen's $d = .24$). Similarly, Turkish seafarers had higher anxiety scores than those from other Black Sea countries ($t = 2.644$, df = 353, $P = .009$), also with a small effect size ($d = .29$).

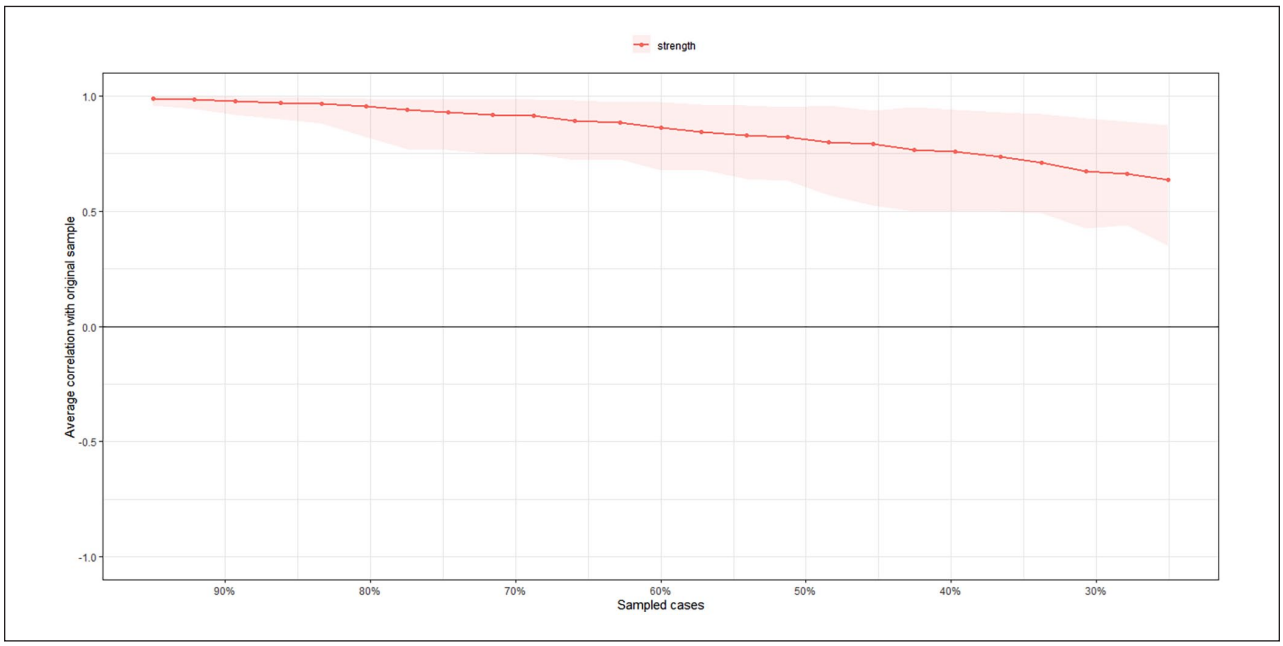


Figure 5. Case-dropping subset bootstrap analysis.

An analysis of variance showed a statistically significant difference in anxiety levels across different ranks ($F=4.137$, $P<.001$), with a medium effect size ($\eta^2=0.067$). Post-hoc comparisons revealed that deck officers and engineers exhibited higher anxiety than masters and chief engineers. Furthermore, anxiety levels were significantly associated with sea experience ($F=4.589$, $P=.001$, $\eta^2=0.050$), indicating higher anxiety among less experienced seafarers. These findings suggest that younger age, Turkish nationality, lower rank, and limited sea experience may be contributing factors to elevated anxiety symptoms among seafarers in the post-COVID-19 context.

According to the BDI-II results, 38.8% of seafarers exhibited symptoms of depression, with 17.7% reporting mild, 16.9% moderate, and 4.2% severe levels of depression (Figure 6). Similarly, based on the GAD-7 scale, 56.7% of seafarers showed symptoms of anxiety, with 46.5% experiencing mild, 8.5% moderate, and 1.7% severe anxiety (Figure 6).

The GGM network structure created to examine the relationships between seafarers' depression, anxiety levels, ship-related issues, port-related issues, and career planning themes is shown in Figure 7. Thick edges in the network represent strong relationships. Green edges indicate positive relationships, while red edges denote negative relationships. Each theme is represented by different color codes. Additionally, the obtained EI and BEI results and edge weights are presented in Table 3.

According to the results of the GGM analysis, the variables with the highest EI values were Anxiety (EI=0.886) and Depression (EI=0.664), indicating their central role in the overall network structure. Within the "Ship-related issues" category, the node representing a tense working environment (SRI5) exhibited a high EI value of 0.683, followed by excessive alcohol consumption on board (SRI3; EI=0.554) and pressure from superiors (SRI2; EI=0.468). In contrast, the node concerning health support on board (SRI6) had the lowest EI score (EI=−0.007), reflecting minimal influence.

In the "Port-related issues" theme, pressure from port authorities (PRI3) stood out with an EI of 0.495, whereas other nodes in this group had relatively lower influence. The career planning item (CP1), referring to thoughts of quitting sea work, had a modest EI of 0.271.

In terms of BEI, Anxiety (0.886) and Depression (0.719) again emerged as key bridging variables. Among the ship-related items, the tense working environment (SRI5) served as the strongest bridge (BEI=0.399), while in the port-related category, feeling of isolated (PRI2; BEI=0.298) and pressure from port authorities (PRI3; BEI=0.214) held moderate bridge roles. The career planning item (CP1) had a BEI of 0.287, indicating its potential as a connector across domains, albeit weaker than SRI5.

Discussion

In the current study, 38.8% of seafarers were found to exhibit symptoms of depression, including mild (17.7%), moderate (16.9%), and severe (4.2%) levels as measured by the BDI-II scale. In a study conducted with the BDI scale during the early stages of COVID-19, this rate was reported as 41.7%.[25] Research conducted prior to the COVID-19 period reported

Table 2. Analysis of the Difference in Depression and Anxiety Mean Scores Based on Seafarers' Socio-Demographic Characteristics.

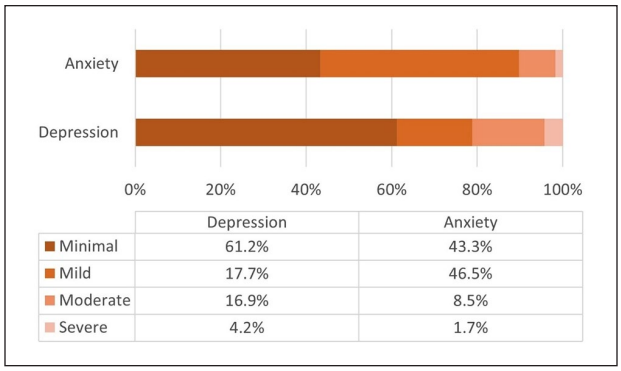
Socio-demographics	n	%	Depression means	Standard deviation of depression scores	Depression test	Anxiety mean	Standard deviation of anxiety scores	Anxiety test
Gender								
Female	26	92.7	1.635	0.904	$t = -0.516$	1.669	0.687	$t = -1.520$
Male	329	7.3	1.731	0.962	SD = 353	1.885	0.816	SD = 353
					$P = .606$			$P = .129$
Age								
18-30	190	53.5	1.716	0.905	$t = 1.642$	1.763	0.676	$t = 2.282$
31 and above	165	46.5	1.556	0.906	SD = 353	1.594	0.715	SD = 339.8
					$P = .101$			**$P = .023$***
								$d = .24$
Nationality								
Türkiye	221	62.3	1.661	0.933	$t = 0.490$	1.760	0.727	$t = 2.644$
Other Black Sea countries	134	37.7	1.612	0.866	SD = 353	1.560	0.631	SD = 353
					$P = .625$			**$P = .009$***
								$d = .29$
Marital status								
Married	151	42.5	1.536	0.855	$t = 1.924$	1.616	0.738	$t = 1.571$
Single	204	57.5	1.721	0.939	SD = 338.3	1.735	0.665	SD = 303.4
					$P = .055$			$P = .117$
Rank								
Master	42	12.0	1333	0.816	$F = 1.921$	1.405	0.665	$F = 4137$
Deck officer	106	30.2	1764	0.972	$P = .077$	1.840	0.719	**$P = .000$***
Deck crew	39	11.1	1692	0.922		1.641	0.668	**$\eta 2 = 0.067$**
Chief engineer	27	7.7	1370	0.742		1.370	0.492	
Engineers	32	9.1	1875	0.907		1.906	0.734	
Engine crew	22	6.3	1636	0.790		1.455	0.596	
Cadets	83	23.6	1651	0.916		1.723	0.686	
Sea experience								
Less than 1 year	74	20.8	1.689	0.906	$F = 2.234$	1.689	0.739	$F = 4589$
Between 1 and 3 years	67	18.9	1.806	0.004	$P = .065$	1.791	0.591	**$P = .001$***
Between 4 and 9 years	99	27.9	1.727	0.913		1.849	0.747	**$\eta 2 = 0.050$**
Between 10 and 14 years	63	17.8	1.460	0.800		1.524	0.644	
More than 15 years	52	14.6	1.423	0.848		1.423	0.637	
Vessel type								
Bulk carriers	146	41.1	1.610	0.920	$F = 0.262$	1.644	0.672	$F = 0.473$
Tankers	131	36.9	1.687	0.887	$P = .770$	1.725	0.691	$P = .623$
Others	78	22.0	1.628	0.927		1.692	0.761	

t = independent samples t-test scores; F = one-way ANOVA scores; d = Cohen's d coefficient; η^2 = Eta squared coefficient; P = P value.
*Statistically significant.

depression rates among seafarers ranging from 10% to 37%.[14-16] The study findings indicate that seafarers' levels of depression remain higher than in the pre-pandemic period, with only limited improvement observed compared to the early stages of the pandemic.

Similarly, the GAD-7 results show that 56.7% of the participants experienced symptoms of anxiety. Studies conducted before the COVID-19 period reported anxiety rates among seafarers as 17% and 30% respectively.[15,16] Research conducted during the pandemic indicates that, like depression levels, anxiety levels also showed a significant increase compared to the pre-pandemic period.[5,41] Although the results of this study pertain to the post-pandemic period, they demonstrate that the effects on seafarers' mental health persist, and, like depression, anxiety levels have not yet returned to normal levels. In addition, Sharma[42] reported moderate levels of burnout alongside depression and anxiety symptoms among Indian seafarers in the post-COVID era, suggesting a continued psychosocial burden.

Even before the pandemic, research had identified seafaring as a high-risk occupation for mental health. Factors such as chronic sleep deprivation, long voyages, social isolation,



	Depression	Anxiety
Minimal	61.2%	43.3%
Mild	17.7%	46.5%
Moderate	16.9%	8.5%
Severe	4.2%	1.7%

Figure 6. Seafarers BDI-II and GAD-7 results.

limited communication with family, and perceived job insecurity were frequently associated with depression, anxiety, and even suicidal ideation.[14-16] Zamora et al.[16] also reported that social media use was linked to anxiety and depression, while Lefkowitz and Slade[15] found that over 20% of seafarers experienced suicidal thoughts.

A study by Baygi et al.[26] revealed that during the COVID-19 period, officers experienced higher levels of psychological issues compared to the crew members. Additionally, Şenbursa et al.[58] using data collected during the COVID-19 period, found that cadets had 2.8 times worse mental health compared to masters and chief engineers. In this study, the anxiety levels of officers and engineers were found to be higher than those of ratings, although the difference was not statistically significant. Post-hoc analyses indicated that officers and engineers experienced more anxiety than masters and chief engineers, and that personnel with less seafaring experience reported higher anxiety levels than those with more experience. This may be due to the role of experience in enhancing psychological resilience or the heavier workload and pressure associated with officer and engineer ranks.[105-107]

When examining the network structure, EI values reveal the relative impact of each variable within the network and how these effects shape the interrelations among variables. In the network analysis, depression (EI = 0.664) and anxiety (EI = 0.886) emerged as central nodes, exerting significant influence on the overall network structure. This finding supports the hypothesis, frequently emphasized in literature, that depression and anxiety are strongly interrelated.[108,109] Therefore, the results suggest that intervention approaches targeting both variables simultaneously may be more effective.

In the theme of ship-related issues, the SRI5 (tense working environment) node emerged as the strongest bridge element across groups (BEI = 0.399). This finding aligns with previous studies, indicating that workplace changes, lack of managerial support, and peer relationship difficulties increase occupational stress among seafarers.[43] The strong connection between SRI5 and PRI2 (feeling of alienation), a port-related issue (edge weight = 0.1494), suggests that port experiences are closely linked to stress levels on board. This relationship also resonates with prior findings emphasizing the stress-relieving effects of shore leave.[110,111] Furthermore, SRI5 showed strong intra-group connections with SRI3 (excessive alcohol use on the ship) and SRI2 (pressure from superiors), indicating that a tense working environment on board is closely associated with alcohol use and hierarchical pressure, in line with existing literature.[112,113] In this context, interventions targeting SRI5 (tense working environment) may serve as a bridge, potentially triggering improvements or deteriorations in related clusters. Zhao et al.[35] found that post-pandemic intensification of inspection regimes and administrative duties increased seafarers' fatigue and psychological burden, possibly contributing to the perception of a tense working environment captured by SRI5. This aligns with the broader trend of heightened regulatory pressure in the post-pandemic period, which exacerbated pre-existing stressors such as social isolation and workload, thereby intensifying the tense ship environment (SRI5).

In the theme of port-related issues, the nodes PRI2 (feeling of alienation) and PRI3 (perceived pressure from port authorities) appear to function as potential bridge elements (BEI = 0.298 and 0.214, respectively; see Table 3). However, these values are lower than the BEI of SRI5 (tense working environment) at 0.399, indicating that although these nodes are meaningful, their overall influence on the network is more limited. Edge weights reveal a strong connection between PRI3 and PRI4 (belief that port workers are not adequately following pandemic measures), suggesting that in ports with more authoritarian management, perceived compliance with rules tends to be weaker. While the literature remains divided on the effect of authoritarian leadership on safety behavior.[114,115] Our findings suggest that oppressive attitudes in port environments may negatively influence seafarers' perceptions of safety. Nonetheless, the relatively low BEI values imply that improvements in these nodes may not substantially alter the overall network structure. While port-related issues statistically show weaker effects than onboard factors, their indirect impact on ship operations and the psychosocial environment is significant. These issues increase workplace tension and symptoms of depression and anxiety, reinforcing a detrimental cycle in psychological well-being. Consequently, interventions and policy recommendations addressing port-related problems are as important as those targeting onboard issues and should be approached holistically.

In the theme of "career planning," the thought of leaving the job at sea (CP1) emerged as a single prominent node, with a BEI value calculated at 0.287 (Table 3). This level of influence is lower when compared to "tense working environment" (SRI5, BEI = 0.399). Indeed, CP1 appears more as an outcome variable within the network structure and, by its nature, has limited potential as a direct target for intervention. Edge weight analyses revealed that CP1 had

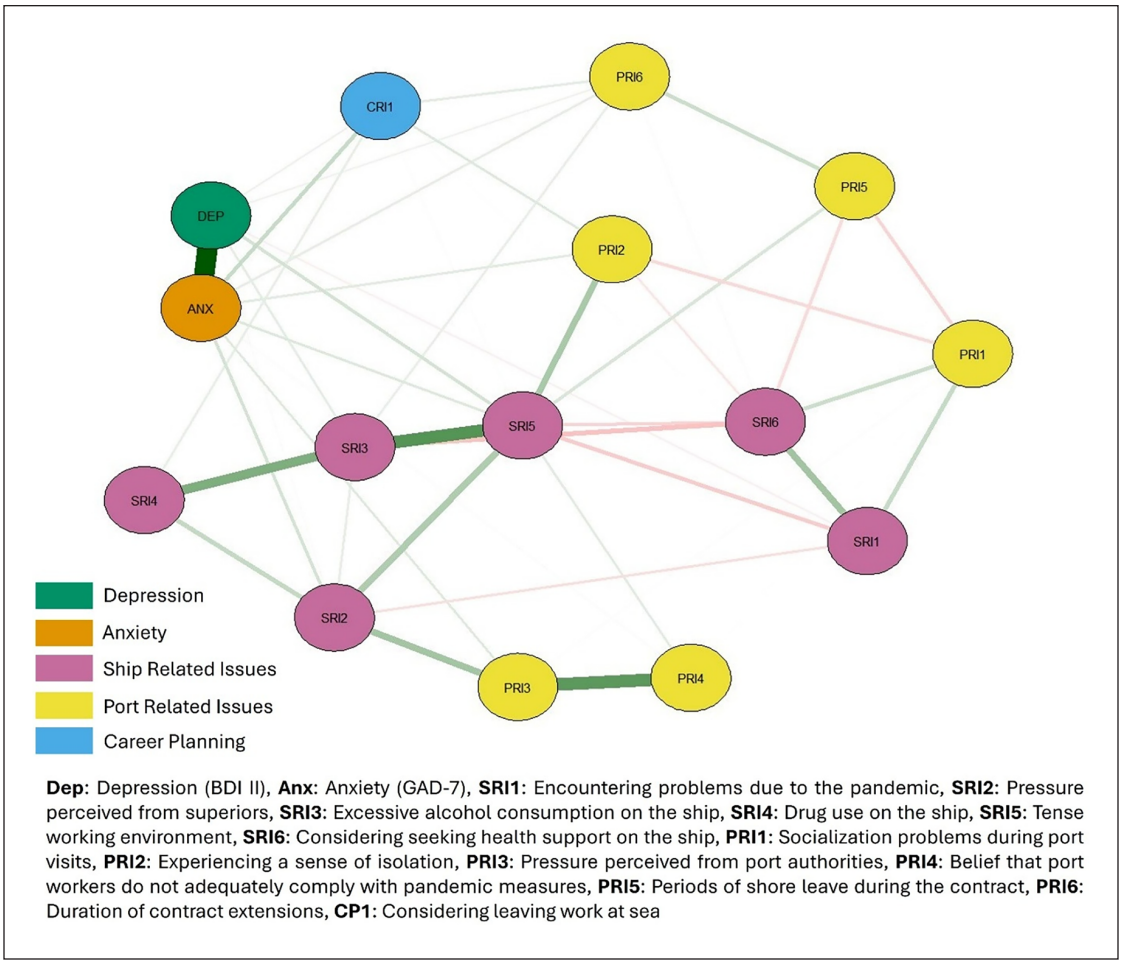


Figure 7. GGM network.

its strongest connection with the anxiety variable (0.0943), suggesting that high levels of anxiety may trigger thoughts of leaving the seafaring profession. In the literature, seafarers' intention to quit has been linked to factors such as social isolation, intense work pace, physical exhaustion, unfair contracts, and prolonged absence from land.[34,116] Notably, Svetina et al.[34] highlighted that social isolation and bullying were key determinants among seafarers considering career withdrawal. While our findings also suggest a possible link between anxiety and career planning, the wide confidence interval (Figure 3) limits the certainty of this relationship. Therefore, further research is needed to confirm this result and to better understand the nature of the relationship.

Based on these findings, several practical and policy-level recommendations can be made: Streamline inspections: Collaborate across stakeholders (port states, flag states, terminals) to develop integrated inspection models, reducing redundant audits (eg, SIRE (Ship Inspection Report Program), CDI (Chemical Distribution Institute)) that exacerbate stress. Strengthen alcohol controls: Enforce stricter entry-point checks for shore personnel and crew during port calls to uphold zero-tolerance policies. Onboard mental health systems: Integrate periodic assessments, confidential counseling, and support lines into Safety Management Systems (SMS). Support junior officers: Implement peer mentoring and resilience training to address higher anxiety levels among less experienced seafarers. Curriculum reform: Maritime academies should incorporate mental health modules (coping strategies, distress identification). Leadership interventions: Target tense work environments through improved communication, workload balance, and leadership training. Expand post-contract evaluations: Include psychosocial indicators (eg, pressure from superiors, alcohol use) alongside operational metrics.

This study was conducted during a specific time window and focused on seafarers from Black Sea countries, which may limit the generalizability of findings. Mental health indicators were measured using self-report scales (BDI-II and GAD-7), which are subject to individual bias. Future research should include longitudinal designs, qualitative

Table 3. EI and BEI results and edge weights.

Nodes	EI	BEI	Edge	Node1	Node2	Weight	Edge	Node1	Node2	Weight
DEP	0.664	0.719	2	ANX	DEP	0.5042	22	SRI5	ANX	0.0563
ANX	0.886	0.886	67	SRI5	SRI3	0.3080	34	SRI2	SRI1	−0.0561
SRI1	0.039	0.175	162	PRI4	PRI3	0.2952	26	PRI3	ANX	0.0533
SRI2	0.468	0.243	66	SRI4	SRI3	0.2276	25	PRI2	ANX	0.0500
SRI3	0.554	0.082	38	SRI6	SRI1	0.1620	102	PRI4	SRI5	0.0477
SRI4	0.368	0.040	56	PRI3	SRI2	0.1606	210	CRI1	PRI6	0.0463
SRI5	0.683	0.399	100	PRI2	SRI5	0.1494	5	SRI3	DEP	0.0438
SRI6	−0.007	0.165	52	SRI5	SRI2	0.1384	50	SRI3	SRI2	0.0418
PRI1	0.028	0.185	68	SRI6	SRI3	−0.1047	40	PRI2	SRI1	−0.0418
PRI2	0.149	0.298	51	SRI4	SRI2	0.1007	29	PRI6	ANX	0.0415
PRI3	0.495	0.214	39	PRI1	SRI1	0.0976	90	CRI1	SRI4	0.0398
PRI4	0.353	0.063	30	CRI1	ANX	0.0943	74	PRI6	SRI3	0.0378
PRI5	0.017	0.127	114	PRI1	SRI6	0.0879	15	CRI1	DEP	0.0319
PRI6	0.226	0.169	37	SRI5	SRI1	−0.0870	14	PRI6	DEP	0.0285
CP1	0.271	0.287	194	PRI6	PRI5	0.0864	3	SRI1	DEP	−0.0275
			98	SRI6	SRI5	−0.0754	27	PRI4	ANX	0.0158
			133	PRI5	PRI1	−0.0722	119	PRI6	SRI6	−0.0145
			7	SRI5	DEP	0.0717	131	PRI3	PRI1	−0.0144
			19	SRI2	ANX	0.0707	4	SRI2	DEP	0.0117
			130	PRI2	PRI1	−0.0654	105	CRI1	SRI5	0.0099
			103	PRI5	SRI5	0.0645	45	CRI1	SRI1	−0.0081
			118	PRI5	SRI6	−0.0622	132	PRI4	PRI1	−0.0052
			150	CRI1	PRI2	0.0567				

EI = expected influence; BEI = bridge expected influence.

interviews, and larger, more diverse international samples to further investigate how post-pandemic stressors continue to affect maritime mental health globally.

Conclusion

This study assessed depression and anxiety levels among seafarers from Black Sea countries in the post-COVID-19 period and examined their associations with socio-demographics, shipboard conditions, port-related issues, and career planning. Based on BDI-II and GAD-7 scales, 38.8% of seafarers reported depressive symptoms and 56.7% showed anxiety figures notably higher than pre-pandemic levels. Anxiety was more pronounced among officers and less-experienced seafarers.

Although the direct psychological effects of COVID-19 appear to have declined, network analysis revealed persistent onboard stressors. A tense working environment (SRI5) emerged as the most influential node, bridging symptoms of both depression and anxiety. Strong links also connect tense conditions with alcohol use and pressure from superiors, indicating systemic stress. Port-related factors, though less central, such as perceived authority pressure and isolation, also posed mental health risks.

In conclusion, post-pandemic seafarers still face embedded stressors. Addressing these through integrated policy, company-level interventions, and continued research is vital for promoting long-term mental well-being in maritime contexts.

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Ethical Considerations

The study was approved by the Ethics Committee for Social and Human Sciences Research at Ordu University (Ethical Clearance Reference Number: 2022-34) on March 22, 2022.

Consent to Participate

Participants were informed that the study had received ethical approval, that all collected data would be kept confidential and used solely for scientific purposes, and verbal or written informed consent was obtained from all participants before starting the survey. Even when verbal consent was obtained, participants still completed the written "Voluntary Participation Form" approved by the Ethics Committee, as required by the ethical protocol.

Author Contributions

Fırat Sivri: Conceptualization, Methodology, Formal Analysis, Software, Visualization, Writing – Original Draft, Writing

– Review and Editing, Supervision, Data Curation. Özkan Uğurlu: Methodology, Validation, Formal Analysis, Writing – Review and Editing, Investigation. Eduardo Blanco-Davis: Methodology, Writing – Review and Editing, Resources, Investigation. Nihan Şenbursa: Methodology, Writing – Review and Editing, Investigation, Data Curation. Jin Wang: Methodology, Writing – Review and Editing, Resources, Investigation, Validation.

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Declaration of Conflicting Interests

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Data Availability Statement

The datasets utilized and/or analyzed during this study are accessible from the corresponding author upon request.

Supplemental Material

Supplemental material for this article is available online.

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