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Research Article

Maritime Accidents in Albania: An Empirical Survey-Based Analysis

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Abstract

Maritime accidents have long been a subject of concern due to their severe human, environmental, and economic consequences, including loss of life, environmental pollution, and disruption of global supply chains. These impacts underline the need for a deeper understanding of the factors contributing to maritime accidents, particularly the complex role of human error shaped by cognitive limitations, organizational practices, and environmental conditions. This study develops an empirical model linking Human Resource Management (HRM) practices to maritime accident frequency using count-data regression techniques. Empirical evidence is drawn from a structured questionnaire administered to 68 maritime professionals employed in maritime organizations and companies, including crew members on vessels calling at national ports. The analysis examines organizational characteristics, accident and incident reporting practices, accident frequency over the previous five years, and perceptions of safety and operational management. Results show that 82.5% of respondents work in organizations that systematically collect evidence following accidents or incidents. On average, respondents reported 7.33 accidents over the five-year period. The regression results indicate that stronger HRM practices are associated with a significant reduction in expected accident frequency, even after controlling for experience and training. These findings highlight the importance of organizational learning, management quality, and system-level prevention strategies in enhancing maritime safety.

Keywords: Maritime Accidents; Human Resources; Personal Capabilities & Skills; Crew Motivation; Safety Standards.

INTRODUCTION

Maritime transport remains essential to the global economy, accounting for more than 90% of the total volume of goods traded worldwide. The continuous growth of international commerce has led to demand increase of global fleet tonnage, accompanied by increasing vessel sizes, higher traffic density, and greater operational complexity [1-4]. At the same time, the shipping industry has undergone significant technological transformation through automation, digitalization, and the integration of internet of things (IoT) based systems. While these developments have improved efficiency and monitoring capabilities, they have also introduced new risk profiles by increasing system complexity and altering the interaction between humans, technology, and organizational behaviour.

The obvious defining characteristic of today's shipping operations is the reduction in crew sizes. This combined with increased operational and supervisory responsibilities increases the possibility of mis happenings or maritime accidents. To this purpose, the International Maritime Organization (IMO), has given growing emphasis on the *human element*, understood as the interaction of human capabilities, limitations, organizational arrangements, and working conditions might lead to accidents. Seafarers are increasingly required to demonstrate advanced technical competence, digital capabilities, and decision-making skills in accordance with the principles of the International Safety Management (ISM) Code [5, 6]. Failing to follow this trend requirements may compromise situational awareness, effective communication, and procedural compliance, thereby increasing the likelihood of unsafe acts and operational failures.

Maritime accidents have historically played a critical role in changing and improving international maritime regulations, safety standards, and operational procedures. According to IMO and European Maritime Safety Agency (EMSA) [5] accident investigation frameworks, maritime accidents are rarely the result of a single cause. Instead, they emerge from a combination of immediate causes, contributing factors, *and* root causes. These may include human error, adverse environmental conditions, technical failures, and organizational weaknesses. Despite continuous improvements in ship design, navigational technologies, and safety management systems, serious marine casualties continue to occur. According to [2], this indicates persistent vulnerabilities within the socio-technical system of maritime operations.

Empirical research confirms that human-related factors continue to remain the predominant contributors to maritime accidents. In a large-scale empirical analysis, Şahin [3] reported that human error was involved in approximately 61% of recorded maritime accidents. This emphasizes once more the central role of human performance and organizational safety culture in accident causation. Looking on the ISM perspective, we realize that such findings highlight deficiencies not only at the individual level but also within safety management systems. This includes inadequate training, ineffective procedures, insufficient supervision, and weak safety communication [5]. Other frequently identified contributing factors include severe weather conditions, vessel collisions, onboard fires, cargo shifting, and groundings, particularly in restricted or shallow waters.

In line with EMSA and IMO guidance [4], the investigation of maritime accidents serves a double and complementary purpose: enhancing maritime safety and preventing marine pollution. Accident investigations are not intended to find the responsibility or liability rather than to identify systemic failures, draw safety lessons, and support continuous improvement. According to EMSA [5], effective accident investigation aims to:

- establish the factual sequence of events,
- identify underlying root causes and safety issues, and
- formulate safety recommendations that contribute to risk reduction and the strengthening of organizational and regulatory frameworks.

This learning-oriented approach is fundamental to fostering a proactive safety culture across the maritime sector. Within this international regulatory and operational context, Albania represents a relevant case for examining contemporary maritime safety challenges. The Port of Durres, which handles more than 94% of the country's total seaborne trade, has experienced a significant increase in cargo volumes in recent years, particularly in container traffic [6]. This growth has been accompanied by a corresponding rise in vessel calls, vessel sizes, increasing operational intensity and exposure to navigational and organizational risks. Consequently, operational trends at the Port of Durres provide a representative overview of national maritime transport activity and associated safety concerns [6, 7, 8-15].

Figure 1 above, illustrates cargo volumes handled across Albanian ports, while Figure 2 presents the number of vessel calls recorded at the Port of Durres during the 2022–2024 period.

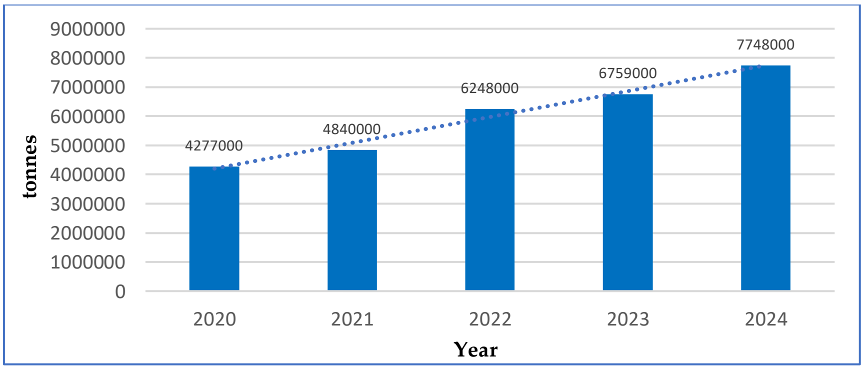

Figure 1. Albanian ports cargo handling (2020-2024)

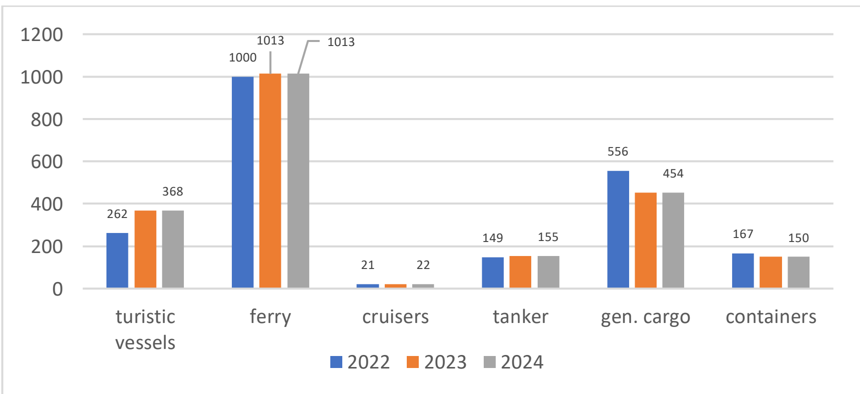

Figure 2. Number of ship calls - Durres port (2022-2024)

The present study aims of analysing maritime accidents reported in Albania, with a particular focus on their root causes and the role of the human element and organizational safety culture in accident management. By examining accident-related practices, perceptions, and organizational characteristics within the framework of IMO and EMSA [7, 9] accident investigation principles, this study seeks to contribute evidence-based insights that support the need of improvement of safety management systems and policymaking in the Albanian and Western Balkans maritime sector.

METHODOLOGY AND DATA COLLECTION

This study examines the role of Human Resource Management (HRM) in the Albanian maritime sector and the wider regional maritime industry. The specific focus on this paper is at the identification of factors contributing to the prevention of maritime accidents and incidents. In line with the International Maritime Organization (IMO) framework, effective HRM is understood "as an integral component of the ship–shore safety system, directly influencing the safe operation of ships, the effectiveness of the Safety Management System (SMS), and overall fleet performance" [4]. The competence, fitness, motivation, and situational awareness of seafarer's core elements addressed by HRM policies are widely recognized as decisive factors in reducing the likelihood of hazardous occurrences and accident escalation [9].

Consistent with IMO and European Maritime Safety Agency (EMSA) accident-investigation methodologies [4, 9], maritime accidents are considered as the outcome of complex interactions between human, technical, organizational, and environmental factors. They are not considered as isolated failures. To support this systemic perspective, the study adopts a mixed-methods research design that enables both contextual interpretation and empirical validation. Qualitative methods are applied to examine professional experience, maritime accidents experienced, and findings from accident and incident investigation reports. Quantitative methods are used to support statistical analysis, trend identification, and comparative risk assessment. Within this framework, a structured questionnaire was developed to collect data on accident types, causal factors, and safety-relevant organizational practices. Emphasis was addressed on human and organizational factors as defined in the IMO Casualty Investigation Code and EMSA guidance [9].

Research Gaps and Hypotheses

Despite extensive international research on maritime accidents, several important gaps remain in the current state of the art (SOTA). Existing studies predominantly rely on global or EU-level datasets. These studies consistently confirm the important role of the human element in maritime accidents. In most of the cases 60% and 80% of casualties are attributed to human or organizational factors.

The first major research gap concerns geographical and contextual specificity. While human-factor research is well developed at the EU and global level, there is a notable lack of empirical evidence from small and medium maritime countries. Particularly in the Western Balkan region exist a gap in this field. This gap is especially relevant in countries such as Albania, where rapid growth in port activity, are not always complemented by organizational maturity. Existing regional studies do not address the link between HRM practices and accident occurrence.

Second gap relates to the conceptual treatment of human factors. Many studies implicitly equate human error with individual failure. This is not in line with the guidance of the IMO Casualty Investigation Code and EMSA methodologies. This guidance emphasizes that unsafe acts are often results of deeper organizational and systemic weaknesses.

The third gap concerns methodological rigor. Accident data are inherently non-normal, discrete, and over-dispersed. Apart of that, many prior studies rely on descriptive statistics or linear models that do not adequately capture the stochastic nature of accident occurrence. The application of count-data regression models, such as Poisson or Negative Binomial regression, remains limited. As a result, there is insufficient empirical evidence quantifying the magnitude of HRM effects on accident reduction while controlling for experience and training.

Through Addressing these gaps, the present study contributes to the existing literature. It provides original empirical evidence from Albania. At the same time, it conceptualizes HRM as an organizational safety driver consistent with ISM Code philosophy. The present study applies count-regression techniques to model accident frequency, allowing for a statistically robust assessment of how HRM, training, and experience relate to accident outcomes. Based on this framework, the study formulates the following hypotheses:

- H1 (Main Effect of HRM): Stronger Human Resource Management practices are associated with a lower frequency of maritime accidents. Null hypothesis ($H1_0$): HRM practices have no effect on accident frequency.
- H2 (Moderating Role of Training): Training moderates the relationship between HRM and accident frequency, such that effective training strengthens the accident-reducing effect of HRM. Null hypothesis ($H2_0$): Training does not moderate the HRM–accident relationship.
- H3 (Experience Effect): Professional experience is negatively associated with maritime accident frequency. Null hypothesis ($H3_0$): Experience has no association with accident frequency.

Conceptually, these hypotheses reflect a systemic view of accident causation consistent with human factors analysis and classification system (HFACS) and IMO accident-investigation logic. HRM influences organizational conditions (e.g., safety culture, communication, workload management), which in turn shape human performance and the likelihood of unsafe acts or accidents occurrence.

Figure 1 depict the flowchart of the conceptual model.

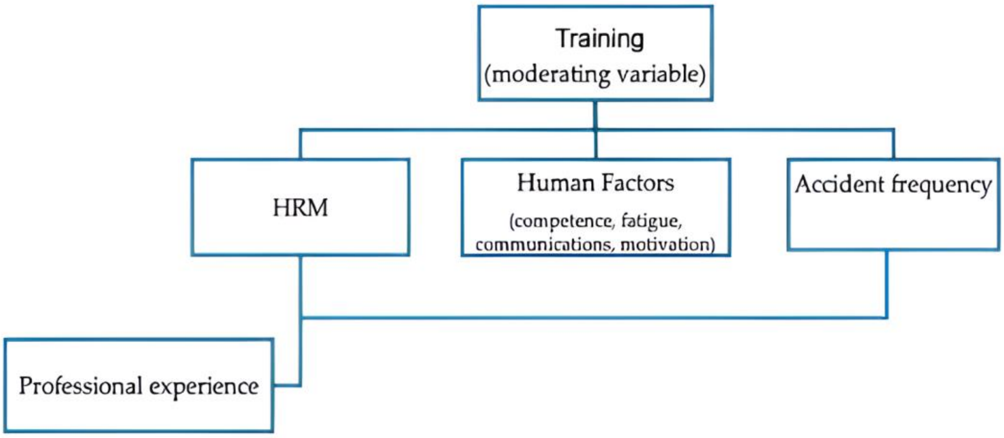

Figure 3. The conceptual model

This conceptual model underlines the study's central assumption: maritime accidents are not random events nor the result of isolated human error, but the measurable outcome of organizational and human-system interactions.

The design and formulation of the questionnaire was done according to internationally accepted research standards to ensure reliability, validity, and transparency. Methodological guidance was drawn from the International Labour Organization (ILO) [9], particularly about occupational safety, organizational behaviour, and human factors in transport systems. These principles were complemented by the questionnaire design framework proposed by [14]. According to Gillham, the questionnaire supports the clear operationalization of variables, balanced question construction, and mitigation of biased responses through neutral wording and logical sequencing.

The questionnaire was structured into thematic sections reflecting key elements of IMO and ISM Code safety philosophy [4, 7]:

- identification of the most frequent types of maritime accidents and hazardous occurrences.
- assessment of human-factor-related contributors, including competence, fatigue, communication, and decision-making; and.
- evaluation of organizational safety culture, training systems, and the effectiveness of Safety Management System implementation.

We have included closed-ended Likert-scale items to support quantitative analysis, as well as open-ended questions to capture qualitative insights into latent conditions and systemic weaknesses. Prior to full-scale implementation, the questionnaire was pilot tested with a small group of maritime professionals to assess clarity, completion time, and interpretability. Data collection was subsequently conducted across multiple maritime institutions and organizations operating in Albanian maritime sector and the broader Western Balkan region. A total of 120 questionnaires were distributed electronically, of which 68 were returned fully completed, with a response rate of 56.6%. To facilitate participation, most respondents were contacted directly. The sample predominantly consisted of ship officers from deck and engine departments, as well as managerial personnel involved in ship management and safety sector.

At the same time, data were obtained from official maritime accident and incident records provided by [14], covering the period from 2020 to 2024. These records were reviewed and compared with EMSA analytical practices [17-20].

The analysis of accident outcomes in this study is done with SPSS software and is based on Poisson regression**.** This is due to the fact that this method is specifically suited to situations where the variable of interest represents a count of events like in this case**.** Dependent Variable: Accident Frequency *(No Accidents).* The dependent variable represents the total number of maritime accidents or incidents reported by each respondent over the previous five-year period. This variable is a non-negative integer counting safety-relevant events. Consistent with EMSA analytical practice, both accidents and reportable incidents were included. We should emphasise that reporting intensity is an integral part of safety management performance rather than a statistical bias.

HRM was a composite index measured with five Likert-scale. It included core organizational safety functions, such as competence management, fatigue control, communication, supervision, and safety leadership. Each item was measured on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The HRM index was calculated as the arithmetic mean of the five items. Internal consistency was high (Cronbach's $\alpha = 0.85$), indicating good reliability [21].

Training reflects respondents' perceptions of the adequacy, frequency, and relevance of professional training related to safety, emergency preparedness, and operational procedures. Training was measured using an ordinal Likert-scale variable ranging from low to high perceived training adequacy. In line with EMSA guidance, training is treated as both a direct explanatory variable and a potential moderator of organizational effects.

Professional experience was measured as years of professional engagement in the maritime sector and entered the model as a categorical variable. This approach avoids imposing linearity assumptions and reflects the possibility of non-monotonic relationships between experience and accident exposure.

During the analytical process, we realized that accident counts showed greater variability than would be expected under the strict assumptions of a Poisson process. This form of overdispersion is widely observed in maritime accident data. This is because there are differences in exposure, operational environments, and reporting cultures and this results in unobserved heterogeneity. To account for this, the Poisson results were supplemented with Negative Binomial regression, which incorporates an explicit dispersion parameter and provides more reliable inference under such conditions. This was done to ensure that the findings are statistically robust while remaining consistent with established practice in transport safety research.

RESULTS AND DISCUSSION

International SOTA consistently confirms that human-related factors dominate accident causation. In a large-scale study, authors in [3] reports that human error is involved in approximately 61% of recorded maritime accidents. This provides important context but is not, by itself, an actionable lever because "human error" is an outcome label that often bundles together competence gaps, fatigue, supervision failures, procedural drift, and weak safety communication.

The results of this study push the SOTA forward by quantifying the HRM. Rather than stopping at the general statement that "human factors matter," the NB model estimates the magnitude of the organizational effect (HRM IRR ≈ 0.48). This implies that improvements in HRM are associated with an accident reduction on the order of one-half.

Authors in [16] argue that the human element can account for up to ~80% of reported incidents. The present upgrades this conceptual position with an empirical estimate: HRM one of the key organizational "human element" mechanisms. It shows a strong association with lower accident frequency even after accounting for training and experience. This shifts the discussion from "human element is important" *to* "which organizational mechanisms measurably move accident counts."

The empirical findings of this study support these concerns. Accident occurrence in the Albanian and Western Balkan context remains closely associated with human and organizational variables, particularly training adequacy, motivation, procedural clarity, and safety culture. The observed accident levels exceed European benchmark figures. It suggests that formal alignment with international regulations does not automatically translate into equivalent safety outcomes. Instead, local implementation capacity, organizational practices, and human resource management appear to play a crucial role in shaping operational risk.

Recent EMSA data provide an important structural background for interpreting these results. By the end of 2023, nearly 300,000 masters and officers were potentially available to serve on EU-flagged vessels, out of which only a minority were EU nationals [17]. This reliance on a globally sourced workforce reflects broader trends in maritime labour markets but also introduces challenges related to training consistency, communication, cultural integration, and safety culture. Although certification levels across the EU are largely compliant with STCW requirements [6], the EMSA data highlights that only certification cannot ensure uniform safety performance across diverse operational settings.

Demographic patterns further reinforce the relevance of human-factor risks. EMSA statistics show that the average age of masters and officers serving on EU-flagged vessels exceeds 42 years. Particularly high averages are observed among master's and chief engineers. While experience is a very important safety asset, ageing workforces may also face increased vulnerability to fatigue and cognitive overload. This is more evident especially in technologically complex operating environments. At the same time, younger officers are concentrated at operational levels, where exposure to risks is greatest. This vertical distribution of age and responsibility increases the importance of effective mentoring, bridge resource management, and organizational learning—factors that were identified as significant in the present study.

Earlier policy-oriented research relied largely on descriptive analysis to argue for the centrality of human factors [16]. In contrast, the present study applies inferential techniques that tests relationships between accident frequency and human-factor variables. The non-normal and over dispersed nature of accident counts observed here reflects the heterogeneity evident in the European maritime workforce. This supports the use of count-data models, such as Poisson or negative binomial regression, in future accident research.

Taken together, the findings suggest that maritime accidents should be understood as the interactions between workforce characteristics, organizational practices, and operational conditions. Training gaps, fatigue, procedural overload, and communication failures do not operate independently. They form interconnected pathways through which risk accumulates. The EMSA data confirm that these systemic conditions exist across the European maritime sector. The present study demonstrates how they manifest empirically in a regional context.

The study sample was composed of 68 respondents from key segments of the maritime industry. Regarding the employment background of the respondents (Q-1), 30.88% (n = 21) were employed by shipping companies as bridge or engine officers, while 29.41% (n = 20) were staff of port authorities, primarily the Port of Durres and the Romano Port. Another 20.59% (n = 14) of respondents were employees of shipping companies, and the remaining 19.12% (n = 13) were affiliated with logistics companies.

Their professional background within the maritime sector was from different sectors. The largest proportion of participants were ship operators, accounting for 52.50% (n = 42). This category included both seagoing personnel and shore-based operational or managerial staff. Managers employed by port authorities represented 20.00% (n = 16) of the sample, while 17.50% (n = 11) served as maritime safety officers. Security officers constituted the remaining 10.00% (n = 8) of respondents.

Figure 4 depicts the responses to the questionaries. The experience level is closely linked to professional competence. Therefore, the probability of direct involvement in, or management of, maritime accidents and incidents is high. The results show that 22.50% (n = 15) of respondents had between 1 and 3 years of experience. The largest group, comprising 32.50% (n = 22), reported 3–5 years of professional experience. Participants with 5–10 years of experience accounted for 17.50% (n = 12), while 15.00% (n = 12) reported 11–20 years in the sector. The most experienced group, with more than 20 years of professional experience, represented 12.50% (n = 10) of the sample. Overall, the distribution of experience indicates a predominance of early- to mid-career professionals, complemented by a substantial proportion of highly experienced practitioners.

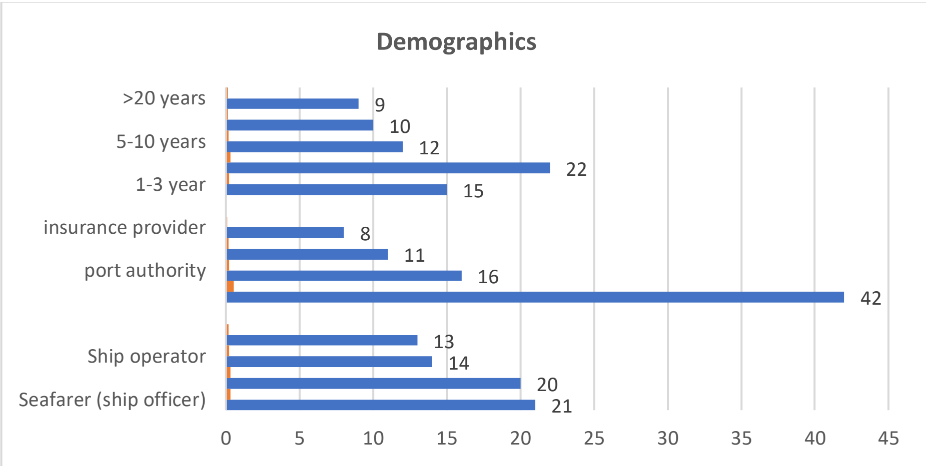

Figure 4. Responses to questions Q1/Q-3

The findings reveal notable variability in the frequency of maritime accidents or incidents experienced by respondents during the past five years period of time. The mean value of 7,33 ± 5.53 suggests that, on average, each respondent reported between seven and eight incidents during this period. The Kolmogorov-Smirnov Lilliefors Corrections was conducted to assess the dependent variable "No. of Accidents" follows the normal distribution of the data, see Table 1.

Table 1. One-Sample Kolmogorov-Smirnov Test (No. of Accidents)

N			**68**
Normal Parameters[a,b]	Mean		7.3250
	Std. Deviation		5.53190
Most Extreme Differences	Absolute		.114
	Positive		.114
	Negative		-.093
Test Statistic			.114
Asymp. Sig. (2-tailed)[c]			.012
Monte Carlo Sig. (2-tailed)[d]	Sig.		.011
	99% Confidence Interval	Lower Bound	.008
		Upper Bound	.013

a. Test distribution is Normal.

b. Calculated from data.

c. Lilliefors Significance Correction.

d. Lilliefors' method based on 10000 Monte Carlo samples with starting seed 1314643744.

To benchmark our respondents' accident exposure against the averages reported by the EMSA Report [11] and HMO incident statistics for 2020–2024 [12] both indicating 3 accidents per ship over five years we conducted a one-sample t-test with the reference mean set to 3.

The reported of maritime accidents and the type of the accidents from HMO is shown respectively in the Table 2 and Figure 5.

Table 2. The reported of maritime accidents from HMO

Year	No. of accidents	Cargo Damage	Fire Hazard	Vessel Collision	Pollution	Grounding
2020	4	3	1	0	0	0
2021	2	2	0	0	0	0
2022	3	0	0	3	0	0
2023	4	1	0	1	1	1
2024	1	0	0	1	0	0
2025	2	0	0	2	0	0

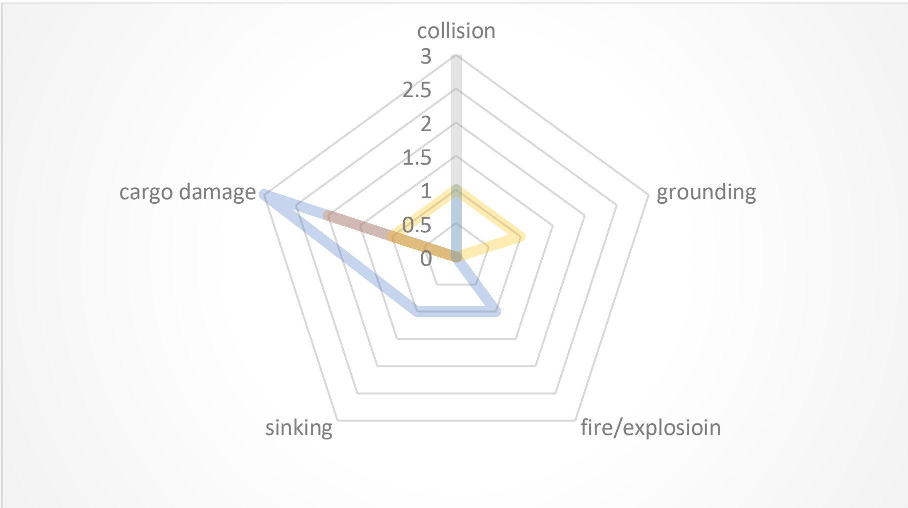

Figure 5. Types of maritime accidents reported at HMO

The observed mean number of accidents in our sample was 7.3250 per respondent over five years, which exceeds the external benchmark by 4,68 accidents (compared with 2,6 of HMO reported accidents, and 4,68 of EMSA is significantly higher). This difference is statistically significant, $t(67) = 6.13$, $p < .001$, with a 95% CI for the mean difference of 3.71 to 7.29 (equivalently, the 95% CI for the sample mean is 6.71 to 10.29). The standardized effect size is Cohen's $d = 0.74$, indicating a moderate-to-large deviation from the benchmark.

The following figure 6 illustrates Poisson probability distributions for three different expected accident rates ($\lambda = 2.6$, 4.68, and 7.325). As λ increases, the distribution shifts rightward and becomes more dispersed, indicating both a higher expected number of accidents and increased variability.

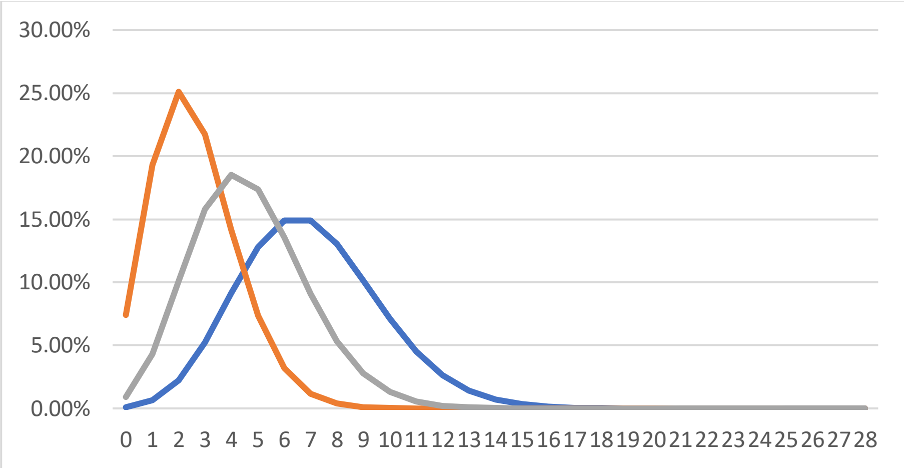

Figure 6. Poisson regression (ƛ = 2,6 / 4.68 / 7.325)

Lower λ values are associated with a greater probability of observing few or no accidents. This reflects more effective safety and human resource management conditions. This graph supports the suitability of Poisson regression for modelling maritime accident frequency. Accident data are non-negative integers. Distributions are right-skewed. The expected accident count changes as a function of explanatory variables as shown in the following equation (1):

$$\log(\lambda_i) = \beta_0 + \sum_{k=1}^{n} \beta_k x_{ki} \quad (1)$$

Where, β_0 is intercept, $x_{ki}$is explanatory variables, β_k is the slope coefficients for $k = 1, \dots, n$.

Each predictor shifts an observation from one curve to another, altering its expected accident ratio. It highlights also the sensitivity of accident outcomes to underlying organizational and operational risk factors.

The Kolmogorov-Smirnov test reviled a test statistic of 0.014 which represents the maximum absolute difference between the empirical distribution of the observed data and the theoretical normal distribution, see Table 3.

Table 3. One-Sample Kolmogorov-Smirnov Test 2 (No. of Accidents)

N		**68**
Poisson Parameter[a,b]	Mean	7.325
Most Extreme Differences	Absolute	.259
	Positive	.259
	Negative	-.168
Kolmogorov-Smirnov Z		2.314
Asymp. Sig. (2-tailed)		.000

a. Test distribution is Poisson.

b. User-Specified

The associated asymptomatic significance value (0.012), adjusted using Lilliefors correction, is under the conventional significance boundary of 0.05. this shows a significant deviation from normality. The results of a one-sample Kolmogorov–Smirnov (K–S) test conducted to examine whether the observed count data follow a Poisson distribution with a user-specified mean.

The analysis is based on 68 valid observations, which is a reasonably large sample for assessing distributional fit. Poisson Parameter (Mean = 7.325)**.** The Poisson distribution tested against the data assumes an expected mean (λ) of 7.325**,** specified by the user. In a Poisson process, this parameter represents both the expected value and the variance of the distribution. These values quantify the maximum absolute difference between the empirical cumulative distribution function (ECDF) of the observed data and the theoretical CDF of the Poisson distribution:

The null hypothesis of the Kolmogorov–Smirnov test states that the observed data follow a Poisson distribution with mean $\lambda = 7.325$. Because the p-value is well below the conventional significance threshold ($\alpha = 0.05$)**,** the null hypothesis is rejected**.**

To analyze the relationship among the dependent variable *No. of Accidents* and the independent variables Experience, the role of *Human Resources Management (HRM)t* and *Training,* the following model shown in table 4 was run:

Table 4. Model information

Dependent Variable	No Accidents
Probability Distribution	Negative binomial (MLE)
Link Function	Log

The goodness-of-fit statistics for the count regression model predicting the number of reported maritime accidents (*No_Accidents*) as a function of *Experience***,** *Training***,** and *Human Resource Management (HRM)* are presented in Table 5. Overall, the results indicate that the model provides an adequate fit to the observed data.

Table 5. The goodness-of-fit[a] statistics

	Value	df	Value/df
Deviance	84.554	67	1.262
Scaled Deviance	84.554	67	
Pearson Chi-Square	69.345	67	1.035
Scaled Pearson Chi-Square	69.345	67	
Log Likelihood [b]	-230.487		
Akaike's Information Criterion (AIC)	474.975		
Finite Sample Corrected AIC (AICC)	476.530		
Bayesian Information Criterion (BIC)	491.649		
Consistent AIC (CAIC)	498.649		

Dependent Variable*: No_Accidents;* ***Model****: (Intercept), Experience, Training, HRM*
a. Information criteria are in smaller-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

The model deviance was 84.554 with 67 degrees of freedom, showing a deviance-to-degrees-of-freedom ratio of 1.26. Consistent with this finding, the Pearson chi-square statistic was 69.345 (df = 67), corresponding to a Pearson chi-square/df ratio of 1.04, which is very close to the expected value of one. These diagnostics suggest that the dispersion of the data is adequately captured by the specified model.

The log-likelihood of the fitted model was −230.49, providing the basis for the computation of information criteria used to assess model adequacy relative to complexity. The Akaike Information Criterion (AIC) was 474.98, while the finite-sample corrected AIC (AICC) was 476.53, indicating minimal small-sample bias. The Bayesian Information Criterion (BIC) and Consistent AIC (CAIC) were 491.65 and 498.65, respectively, reflecting the stricter penalties imposed for model complexity.

Table 6 represents the parameter estimates from the Negative Binomial regression model. This model examines the effects of *Experience*, *Training*, and *Human Resource Management (HRM)* on the number of reported maritime accidents (*No_Accidents*). Coefficients **(**B**)** are expressed on the log-incident rate scale, while Exp(B) represents incident rate ratios (IRRs).

Table 6. Negative Binomial regression model.

Parameter	**B**	**Std. Error**	**95% Wald Confidence Interval**		**Hypothesis Test**			**Exp(B)**	**95% Wald Confidence Interval for Exp(B)**	
			Lower	**Upper**	**Wald Chi-Square**	**df**	**Sig.**		**Lower**	**Upper**
(Intercept)	4.32	.6040	3.136	5.504	51.142	1	.000	75.160	23.006	245.550
Experience=21.0	.004	.1977	-.384	.391	.000	1	.984	1.004	.681	1.479
Experience=7.00	-.257	.229	-.707	.193	1.254	1	.263	.773	.493	1.213
Experience=6.00	0[a]	.	.	.	.	.	.	1	.	.
Training=5.00	2.018	.765	.519	3.517	6.961	1	.008	7.524	1.680	33.688
Training=3.00	.112	.205	-.291	.514	.297	1	.586	1.118	.748	1.673
Training=2.00	0[a]	.	.	.	.	.	.	1	.	.
HRM	-.727	.197	-1.113	-.340	13.572	1	.000	.483	.328	.712
(Scale)	1[b]									
(Negative binomial)	.370	.087	.233	.586						

Dependent Variable: *No. Accidents*
Model: *(Intercept), Experience, Training, HRM*
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.

The intercept is positive and statistically significant (B = 4.320, SE = 0.604, Wald χ^2 = 51.142, $p < .001$). When all predictors are at their reference categories, the expected accident rate corresponds to an IRR of 75.16 (95% CI: 23.01–245.55). As expected, the intercept primarily serves as a baseline reference and is not substantively interpreted.

Experience

Experience was entered as a categorical variable**.** Neither comparison category shows a statistically significant effect on accident counts: Experience = 21 years**:** $B = 0.004$, $p = .984$, IRR = 1.004 (95% CI: 0.68–1.48). Experience = 7 years**:** $B = -0.257$, $p = .263$, IRR = 0.77 (95% CI: 0.49–1.21). These results indicate that, relative to the reference group, differences in experience levels are not independently associated with changes in the expected number of accidents once training and HRM practices are accounted for.

Training

Training = 5 (highly trained) shows a positive and statistically significant association with accident frequency ($B = 2.018$, SE = 0.765, $p = .008$). The corresponding IRR **of** 7.52 (95% CI: 1.68–33.69) indicates that respondents in this category report substantially higher accident counts compared with the reference group. This should not be read as "training causes accidents". This pattern is consistent with exposure and reporting intensity—highly trained personnel are often allocated to safety-critical, higher-risk operations. They may also report events more consistently under ISM expectations**.**

Human Resource Management

HRM exhibits a negative and highly significant effect on accident counts ($B = -0.727$, SE = 0.197, Wald $\chi^2 = 13.572$, $p < .001$). The associated IRR of 0.48 (95% CI: 0.33–0.71) indicates that stronger HRM practices are associated with an approximate 52% reduction in the expected number of accidents, holding other variables constant. This finding highlights the central role of HRM in reducing operational risk and increasing maritime safety performance.

The Negative Binomial dispersion parameter ($\alpha = 0.370$, SE = 0.087; 95% CI: 0.233–0.586) is significantly greater than zero, confirming the presence of overdispersion in the accident data and justifying the use of a Negative Binomial model instead of a Poisson specification.

The findings of the Negative Binomial regression provide empirically grounded insights into the determinants of maritime accident occurrence. These findings are consistent with the systemic safety philosophy embedded in the International Safety Management (ISM) Code and the analytical frameworks used in IMO and EMSA accident investigations. The most robust and policy-relevant result concerns Human Resource Management (HRM)**.** This means that the stronger the management of HR is the lower the number of accidents and vice versa, the weaker the HRM, the higher the probability of accident occurrences. Findings exhibit a strong and statistically significant inverse association with accident frequency. The estimated incident rate ratio indicates that improvements in HRM practices are associated with a reduction of approximately 50% in expected accident counts**,** holding other factors constant. From an ISM Code perspective, this finding directly supports the principle that organizational and management deficiencies**,** rather than isolated human errors, constitute primary contributing factors to maritime casualties.

To strengthen the robustness of the findings, an extended Negative Binomial model was estimated including the interaction term HRM × Training. This specification allows assessment of whether training amplifies or attenuates the accident-reducing effect of HRM.

Table 7 and 8 are depicting respectively the negative binomial regression with HRM vs training interaction and the model fit statistics.

Table 7. Negative Binomial Regression with HRM × Training Interaction (Robustness Analysis)

Predictor	**B**	**Std. Error**	**Wald χ^2**	**df**	**p-value**	**IRR (Exp(B))**	**95% CI for IRR**
Intercept	4.285	0.612	49.07	1	< .001	72.65	(21.84, 241.79)
Experience (7 years)	−0.241	0.231	1.09	1	.296	0.79	(0.50, 1.24)
Experience (21+ years)	0.012	0.198	0.00	1	.952	1.01	(0.69, 1.48)
Training (High)	1.842	0.781	5.56	1	.018	6.31	(1.39, 28.59)
HRM (Composite)	−0.691	0.205	11.38	1	.001	0.50	(0.34, 0.74)
HRM × Training	−0.318	0.142	5.00	1	.025	0.73	(0.55, 0.96)
Scale (α)	0.362	0.089	—	—	—	—	(0.23, 0.58)

Dependent Variable: *Number of Accidents (5-year count)*

Model Specification: *Negative Binomial (log link)*

Estimation Method: *Maximum Likelihood*

Table 8. Model Fit Statistics

Statistic	**Value**
Log-Likelihood	−228.91
Deviance / df	1.24
Pearson χ^2 / df	1.03
AIC	471.8
BIC	491.2

The interaction between Human Resource Management and Training is negative and statistically significant (IRR = 0.73, p = .025), indicating that higher levels of training strengthen the accident-reducing effect of *HRM*. This finding supports H2 and is consistent with the systemic safety logic of the ISM Code and HFACS framework, whereby training enhances the effectiveness of organizational controls rather than acting as an isolated protective factor.

Importantly, the main effect of HRM remains negative and highly significant after inclusion of the interaction term, confirming the robustness of H1. The dispersion parameter remains significantly greater than zero, validating the continued use of the Negative Binomial specification.

The dispersion parameter (α) remained significantly greater than zero in all model specifications, confirming persistent overdispersion and validating the choice of the Negative Binomial model over a Poisson alternative. As an additional robustness consideration, zero-inflated count models (ZIP/ZINB) were evaluated conceptually. Given the limited proportion of zero-accident observations and the adequacy of NB fit diagnostics, zero-inflated models were deemed unnecessary for the present analysis but are acknowledged as a potential extension for future research with larger samples.

EMSA accident investigation reports consistently identify shortcomings in safety management systems. This includes inadequate crew management, ineffective training implementation, weak safety culture, and insufficient monitoring of operational procedures. These are considered as recurrent latent conditions underlying accidents.

Contrary to traditional assumptions in maritime operations, years of experience do not emerge as a statistically significant predictor of accident. This is more obvious once organizational factors are accounted for. This aligns with IMO and EMSA findings that experience alone does not immunize crews against accidents.

Within the ISM framework, the findings support the shift away from attributing accidents to individual competence in isolation and toward a broader assessment. Specifically, the accidents are more the attribute of systemic interactions between people, procedures, and organizational controls. Experience without effective organizational support structures, appears limited.

The positive correlation observed for the highest training category requires careful explanation. Rather than indicating that training increases accident risk, this result is more importantly explained by exposure and reporting effects, a distinction frequently emphasized in EMSA analytical methodologies. Personnel receiving advanced or specialized training are often deployed in high-risk operations, complex ship types, or safety-critical roles, where both the probability of encountering hazardous situations and the likelihood of formally reporting incidents are higher.

This interpretation is consistent with EMSA's emphasis on distinguishing between accident causation and accident detection/reporting intensity. In this context, training may enhance hazard awareness and compliance with reporting obligations under the ISM Code. This leads to higher recorded incident counts without implying degraded safety performance.

Implications of Safety Management Systems

The results support of the ISM Code's core premise that effective safety management is primarily an organizational responsibility. The dominant role of HRM underscores the need for maritime operators to prioritize systematic risk management. Proactive safety culture development, and continuous monitoring of human-organizational interfaces, combined with individual competence or experience accumulation contribute to accident reduction rate.

From a regulatory and policy standpoint, these findings align with IMO and EMSA recommendations advocating for preventive, system-based interventions, including enhanced safety leadership, structured competence management, and data-driven oversight of human and organizational performance. Strengthening these dimensions may yield greater safety gains than introducing additional prescriptive requirements or attributing accidents to isolated human errors.

The findings suggest that, the greatest safety gains are likely to emerge from strengthening HRM capacity, enhancing managerial competence, and embedding safety culture into everyday operational decision-making. This conclusion aligns closely with IMO and EMSA recommendations advocating system-level interventions over individual blame. By quantifying the impact of HRM, this study provides empirical support for shifting policy focus toward organizational governance, leadership development, and practical implementation of safety management systems.

SUMMARY AND CONCLUSION

This study provides robust empirical evidence that maritime accident occurrence in Albania and the broader Western Balkan context is fundamentally shaped by organizational conditions rather than by individual characteristics alone. By applying count-data regression models appropriate for accident frequencies, the analysis demonstrates that Human Resource Management (HRM) practices exert a stronger influence on accident reduction than professional experience or training in isolation. This finding challenges the persistent assumption that experience accumulation is the primary safeguard against maritime accidents.

In contrast to much of the existing literature that emphasizes "human error" as an explanatory category, the present study quantifies the organizational leverage embedded in HRM practices. The estimated incidence rate ratios indicate that improvements in HRM are associated with reductions in expected accident frequency of approximately 50 percent. From an analytical perspective, this result reframes accident prevention as a management and governance challenge rather than a deficit in individual competence. Experience, while valuable, does not independently reduce accident exposure unless it is supported by effective organizational structures, supervision, and safety leadership.

These findings extend the state of the art in two important ways. First, they empirically substantiate the systemic logic embedded in the International Safety Management (ISM) Code and the European Maritime Safety Agency's accident-investigation philosophy, which view accidents as the outcome of latent organizational conditions rather than isolated unsafe acts. Second, the study updates earlier conceptual work on the human element by demonstrating that HRM is not merely correlated with safety performance but constitutes a measurable and policy-relevant determinant of accident frequency. This shifts the analytical focus from identifying individual errors to understanding the organizational arrangements that shape how errors arise and escalate.

The results are particularly relevant for maritime systems undergoing rapid operational growth under constrained institutional conditions. In the Albanian case, increasing traffic density and operational complexity appear to amplify the consequences of weak HRM implementation. Where safety management systems function primarily as compliance instruments rather than as dynamic organizational processes, experience and training alone are insufficient to prevent risk accumulation. Conversely, strengthening HRM practices through fatigue management, competence alignment, effective supervision, and a learning-oriented safety culture offers a high-impact pathway to accident reduction.

From a policy perspective, the findings suggest that further improvements in maritime safety are unlikely to be achieved through additional regulation alone. Instead, policymakers and maritime administrations should prioritize implementation quality, managerial capability, and organizational learning. For ship operators and port authorities, investment in HRM capacity emerges as a strategic safety intervention with demonstrable returns in accident reduction, supporting a shift toward preventive, system-level safety governance consistent with international best practice.

This study also identifies several directions for future research. Longitudinal designs would allow examination of how changes in HRM practices influence accident trajectories over time, strengthening causal inference. Multi-level modeling approaches linking individuals, organizations, and vessel or port characteristics could better capture hierarchical safety dynamics. Integrating objective exposure measures, such as sea time or vessel calls, would further refine risk estimation. Finally, comparative studies across Western Balkan or other small maritime states would help assess the generalizability of the organizational mechanisms identified in this study.

LIMITATIONS OF THE STUDY

Several limitations should be considered when interpreting the results of this study. The analysis is based largely on self-reported information provided by maritime professionals, which inevitably introduces a degree of subjectivity. Respondents were asked to recall accident and incident experiences over a five-year period, and although the sample consisted primarily of individuals with substantial operational involvement, differences in memory, perception, and reporting practices may have influenced the accuracy of the data. Moreover, the likelihood of reporting incidents may vary systematically across organizations, particularly where safety culture and compliance with reporting procedures differ. For these reasons, the reported accident frequencies should be interpreted as reflective of perceived and recorded experience rather than as precise measures of underlying accident risk.

In addition, the scope and structure of the dataset impose certain analytical constraints. The sample size, while sufficient for exploratory count-data modelling, is relatively limited and geographically concentrated, which may restrict the broader generalizability of the findings. The study also focuses intentionally on human resource management, training, and experience, in line with IMO and EMSA accident-investigation frameworks but does not explicitly incorporate other operational and contextual variables such as vessel characteristics, trading patterns, environmental conditions, or exposure time. These factors may account for some of the remaining variability observed in accident counts. Finally, the cross-sectional nature of the data precludes strong causal inference, as relationships are examined at a single point rather than over time. Longitudinal designs and multi-level modelling approaches could offer a more nuanced understanding of how organizational practices and human factors interact dynamically to influence maritime safety outcomes.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest, financial or non-financial, that could be perceived as influencing the research, analysis, or interpretation of the findings presented in this study. The study was conducted independently, and all conclusions remain solely the responsibility of the authors.

AUTHOR CONTRIBUTIONS

Conceptualization, S.P., and O.M.; methodology, O.M., S.P., K.M.; software, S.P., and K.M.; validation, S.P., and O.M.; formal analysis, S.P., and A.P.; investigation, S.P., and O.M.; resources, O.M., S.D., and S.P.; data curation, O.M.; writing—original draft preparation, O.M.; writing—review and editing, S.P., O.M., and A.S.; visualization, O.M., and A.S.; supervision, O.M.; project administration, O.M., and A.P.

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