*CORRESPONDENCE
Ahmad Muzakky
✉ahmadmuzakky703@gmail.com

Occupational Safety, Health, and Environmental (HSE/K3L) Risk Assessment of Ship Agency Personnel During Vessel Clearance Operations at PT Pelindo Marine Service

Ahmad Muzakky[1]*, Nisha Desfi Arianti[1], Tri Mardalena[1]

[1]Karimun University, Indonesia.

ABSTRACT

Purpose of the study: This research aims to comprehensively evaluate K3L risks encountered by ship agency officers at PT Pelindo Marine Service during the ship clearance process and to assess the effectiveness of existing risk control measures.

Materials and methods: A qualitative descriptive case study approach was employed, utilizing the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. Data were collected through direct field observations, in-depth interviews with 10 respondents (ship agency officers, operational supervisors, and HSE officers), structured questionnaires, and analysis of company documents. Risk assessment was conducted using a Risk Assessment Matrix considering likelihood, severity, and risk rating parameters. Data analysis followed the Miles and Huberman model involving data reduction, data presentation, and conclusion drawing.

Results: The study identified five main activity categories with varying risk levels. The highest risk was found in boarding and disembarking activities via pilot ladder (high risk: moderate probability × severe impact), particularly during adverse weather and nighttime operations. Moderate risks were identified for exposure to engine exhaust fumes, work fatigue, and stress from inter-agency coordination. While PT Pelindo Marine Service has implemented various control measures including mandatory Personal Protective Equipment (PPE), toolbox meetings, periodic K3L training, and direct supervision, gaps in individual compliance and limited oversight during peak operational hours remain significant challenges.

Conclusions: The HIRARC-based evaluation revealed that although existing control measures are partially effective, systematic improvements are necessary, particularly for high-risk activities. Strengthening safety protocols, enhancing staff compliance monitoring, implementing digital safety technologies, and fostering a robust safety culture are essential for minimizing occupational accidents and ensuring sustainable maritime operations.

Keywords:
K3L risk evaluation, ship agency personnel, vessel clearance, maritime safety, HIRARC method, occupational hazards, port operations, risk management.

INTRODUCTION

Occupational Safety, Health, and Environment (K3L) management represents a fundamental pillar of contemporary maritime operations, particularly within the complex ecosystem of port activities (Reinhold et al., 2019a, 2019b). In Indonesia, as an archipelagic nation heavily reliant on sea transportation for over 90% of its goods trade (Rinaldy, 2023), robust K3L practices are essential to mitigate the high incidence of occupational accidents reported in port and shipping sectors, where musculoskeletal disorders, slips, falls, and exposure to hazardous substances predominate (Jo et al., 2020). The ship clearance process, encompassing administrative documentation, coordination with port authorities, harbormasters, and field operations such as vessel boarding via pilot ladders, constitutes a critical juncture where ship agency personnel encounter multifaceted occupational hazards including physical (e.g., falls into sea), chemical (e.g., engine exhaust fumes), ergonomic (e.g., repetitive tasks leading to fatigue), and psychosocial risks (e.g., stress from inter-agency coordination) (Sitepu et al., 2020; Zaman et al., 2023).

Indonesian regulatory frameworks underscore the indispensable role of ship agency activities in ensuring seamless maritime traffic and cargo operations. Key legislations include Law Number 17 of 2008 concerning Shipping, which governs port management, ship operations, and seafarer welfare; Government Regulation No. 61 of 2009 (amended by No. 64 of 2015) on Ports, outlining responsibilities of port authorities for safety, navigation aids, and environmental sustainability (Public-Private Partnership Monitor, 2017; Public–Private Partnership Monitor: Indonesia, 2021); and the more recent Minister of Transportation Regulation Number PM 58 of 2021 concerning Port Management and Business, which mandates efficient vessel clearance procedures while emphasizing risk management to support national logistics and economic growth (Israyadi et al., 2022). These regulations align with

international standards from the International Maritime Organization and International Labour Organization, promoting systematic hazard identification, risk assessment, and control methodologies widely applied in Indonesian shipyards and ports (Öztürkoğlu et al., 2019).

At PT Pelindo Marine Service, a key player in Indonesia's port ecosystem, ship agency personnel operate under peak pressures, navigating dynamic conditions like adverse weather, nighttime operations, and high vessel volumes, which amplify risk exposure (Murtadha & Ratni, 2024). Despite implemented controls such as personal protective equipment and training, gaps in compliance persist, highlighting the need for enhanced frameworks (Fairussihan & Dwisetiono, 2022; Muhamid et al., 2018).

The scholarly discourse on occupational safety in maritime contexts has evolved considerably over the past decade, with increasing recognition of the multidimensional nature of risks encountered by port workers (Prilatama & Sopiah, 2022; Walters et al., 2019). Recent bibliometric and systematic literature reviews have mapped research trends in safety management within the shipping industry, highlighting prolific themes such as risk reduction strategies, human behavioral dynamics, occupational health integration, and environmental prevention measures, particularly in high-hazard environments like ports and shipyards (Onyshchenko et al., 2024; Prilatama & Sopiah, 2022). These analyses underscore a shift toward comprehensive frameworks that address not only physical hazards like slips, falls, and chemical exposures but also ergonomic strains, fatigue, and psychosocial stressors prevalent in dynamic port operations (Li et al., 2018).

Larasati et al. emphasized that potential hazards in port environments span the entire spectrum from raw materials to work processes, necessitating comprehensive K3L risk management. This aligns closely with empirical applications of the HIRARC method in Indonesian contexts; for instance, Arianto & Z. (2025) conducted a qualitative risk analysis at Tanjung Perak Port, categorizing hazards in loading/unloading activities and heavy equipment operations into low, medium, and high risks, thereby advocating immediate control measures. Similarly, Bayhun & Demirel (2024) developed a tailored HIRARC model for shipyard operations at PT. X in Madura, Indonesia, systematically identifying primary and secondary hazards as serious threats to worker safety and operational continuity.

This holistic perspective aligns with Wijaya et al., who articulated that the primary objective of Occupational Health and Safety extends beyond worker protection to encompass the control of risks to equipment, assets, and production resources Priyanka & Basaria (2023) reinforced this by examining HIRARC's efficacy in industrial settings, revealing factors like inadequate PPE usage and high-temperature environments as key contributors to accidents, while stressing the need for proactive risk controls. Internationally, Walters et al., 2019; Walters & Wadsworth (2020) critiqued prevailing technical and behavioral safety approaches in container terminals, drawing attention to evolving ill-health trends—such as musculoskeletal disorders and chemical exposures—stemming from containerisation and organizational changes, and calling for worker-centered research. Studies on specialized roles, like ship-to-shore crane operators in Indonesian terminals, further illuminate fatigue from irregular sleep and high-pressure productivity demands, paralleling the psychosocial risks in vessel clearance activities.

Despite the substantial body of literature addressing occupational safety in maritime contexts, several critical gaps persist. Limited research has specifically focused on the unique risk profile of ship agency personnel during vessel clearance processes. The specific application of HIRARC methodology to ship agency operations at Indonesian ports remains underexplored. There is insufficient evidence regarding the relative significance and interrelationships of hazards specifically for ship agency personnel.

The imperative for conducting this research emerges from multiple converging factors. Ship agency personnel constitute a vital yet vulnerable workforce segment within the maritime industry. The absence of comprehensive K3L risk evaluation specific to their operational context represents both an academic gap and a practical concern with direct implications for worker safety, operational efficiency, and regulatory compliance.

This research pursues the following specific objectives: (1) To systematically identify and categorize occupational hazards encountered by ship agency personnel; (2) To assess the likelihood and severity of identified hazards using the HIRARC methodology; (3) To evaluate the effectiveness of existing K3L risk control measures; (4) To identify gaps and deficiencies in current risk management practices; (5) To develop evidence-based recommendations for enhancing K3L risk management

MATERIALS AND METHODS

Study Participants

The research involved a purposively selected sample of 10 participants representing key stakeholder groups within PT Pelindo Marine Service's vessel clearance operations. The sample included ship agency officers, operational supervisors, and Health, Safety, and Environment (HSE) officers.

Study Organization

This research employed a qualitative descriptive approach with a case study methodology to comprehensively explore the phenomenon of K3L risks among ship agency personnel at PT Pelindo Marine Service. The HIRARC analytical framework comprises three integrated phases: hazard identification, risk assessment, and risk control determination. The research was conducted at PT Pelindo Marine Service, a major maritime service provider strategically located in a principal Indonesian port area. The research implementation spanned six months to comprehensively capture operational dynamics across different seasonal patterns, vessel types, and operational intensities.

Test and Measurement Procedures

Data collection employed a triangulated approach incorporating multiple methods. Direct field observations involved systematic documentation of work activities, operational environments, and interactions with hazards. In-depth semi-structured interviews were conducted with all participants to elicit detailed information regarding experiences, perceptions, and understandings of occupational risks. Structured questionnaires complemented interviews by enabling systematic collection of standardized

information. Secondary data collection involved comprehensive review of organizational documents.

Data Analysis Procedures

Qualitative data analysis followed the systematic approach delineated by (Miles et al., 2014), comprising three concurrent activities: data reduction, data display, and conclusion drawing/verification. The Risk Assessment Matrix methodology incorporated likelihood and severity parameters to determine categorical risk levels.

RESULTS

Identification of Work Activities and Associated Hazards

Systematic observation and documentation of vessel clearance operations identified five primary categories of work activities performed by ship agency personnel. These activities encompass the complete workflow from initial vessel arrival through final clearance documentation.

Table 1. Occupational Hazard Identification and Risk Assessment Matrix

No	Work Activity	Types of Hazards	Likelihood	Severity	Risk Level & Existing Control Measures
1	Boarding and disembarking vessel via pilot ladder	Physical hazard: Slipping, falling into the sea, ladder instability	Medium	Severe	HIGH RISK Existing controls: • Mandatory life vest and helmet • Pre-activity safety briefing • Weather condition assessment • Standby personnel for emergency response Gap: Limited effectiveness during adverse weather and nightttime operations
2	Examination of ship documents in boarding area	Chemical hazard: Exposure to engine exhaust fumes, fuel vapors	Medium	Moderate	MODERATE RISK Existing controls: • Respiratory masks provided • Limited exposure duration (time-based rotation) • Ventilated work areas where possible Gap: Inconsistent mask utilization during peak hours
3	Document delivery at pier facilities	Physical hazard: Falling objects from crane operations, vehicle collisions	Low	Severe	MODERATE RISK Existing controls: • Designated pedestrian safety zones • High-visibility vest requirement • Safety barriers and signage • Coordination with crane operators Gap: Compliance challenges during congested periods
4	Administrative work and documentation	Ergonomic hazard: Unergonomic posture, prolonged sitting, repetitive strain	High	Light	MODERATE RISK Existing controls: • Ergonomic chairs and workstations • Scheduled stretching breaks • Rotation of tasks Gap: Limited compliance with break schedules during busy periods
5	Inter-agency coordination (harbor master, immigration, customs)	Psychosocial hazard: Work pressure, time stress, communication difficulties	Medium	Moderate	MODERATE RISK Existing controls: • Daily briefings and coordination meetings • Job rotation to distribute workload • Clear communication protocols Gap: Inadequate stress management support and conflict resolution mechanisms

Evaluation of Existing Risk Control Measures

PT Pelindo Marine Service has implemented a multi-layered risk control framework. Personal Protective Equipment (PPE) provision includes life vests, safety helmets, safety shoes, respiratory masks, and high-visibility vests. Toolbox meetings are conducted before each shift to review safety procedures. Periodic K3L training programs provide quarterly refresher training. Direct supervision by K3L officers provides real-time monitoring, though coverage is constrained during peak operational periods.

DISCUSSION

Interpretation of Research Findings

The findings illuminate the complex and multifaceted nature of occupational hazards confronted by ship agency personnel at PT Pelindo Marine Service. Physical hazards dominate, particularly in boarding and disembarking via pilot ladders, where slipping, falling into the sea, and ladder instability pose severe threats, especially during adverse weather and nighttime operations (Camlıyurt et al., 2023; Kouakou et al., 2022). Despite existing controls such as mandatory life vests, helmets, pre-activity briefings, and standby personnel, the risk remains high, highlighting the limitations of personal protective equipment and administrative measures in addressing inherent environmental and dynamic challenges (Jogie et al., 2025). This persistence underscores that certain hazards, like vertical vessel access, require higher-order interventions beyond the hierarchy of controls' lower tiers (Zaman et al., 2023).

Chemical exposures from engine exhaust and fuel vapors during document examinations, ergonomic strains from prolonged administrative tasks, and psychosocial pressures from inter-agency coordination further compound the risk profile, manifesting as moderate risks across operations (Çakır, 2019; Radić, 2018). Gaps in control implementation—such as inconsistent mask usage during peaks, compliance issues in congested piers, and inadequate stress management—reveal systemic vulnerabilities exacerbated by operational intensities and seasonal variations observed over the six-month study period.

Comparison with Antecedent Research

The findings demonstrate substantial convergence with broader maritime occupational safety literature while contributing unique insights into ship agency workflows. The effectiveness of the HIRARC methodology validates previous applications in diverse maritime settings, including Indonesian shipyards and container handling, where it systematically identified primary and secondary hazards (Fairussihan & Dwisetiono, 2022; Giovanni et al., 2023; Prasetyawati et al., 2024; Ramandaputra et al., 2024; Zaman et al., 2023). Notably, the identification of pilot ladder operations as highest-risk aligns with maritime safety research documenting vertical vessel access as a persistent injury source, with machine learning analyses of accident reports emphasizing workplace factors over environmental ones and frequent missteps during ladder climbs (Çakır, 2019; Camlıyurt et al., 2023).

This study extends prior work by quantifying moderate risks in less-studied areas like document delivery amid crane activities and psychosocial stressors from time pressures, which echo findings on human factors in pilotage and cargo operations but highlight ship agency-specific coordination challenges (Oraith et al., 2021; YORULMAZ & Susoy, 2025). Unlike shipyard-focused

HIRARC studies emphasizing engineering repairs (Zaman et al., 2023), the persistent moderate risks here despite multi-layered controls (e.g., toolbox meetings, quarterly training) point to implementation gaps during peaks, consistent with reports on fatigue and non-compliance in high-density maritime environments (Oldenburg et al., 2021). The pervasive experience of psychosocial stressors, including excessive workload and ineffective communication, further underscores the necessity for improved workload distribution and enhanced communication practices within the maritime industry (Tadee, 2025). These insights collectively underscore the need for continuous evaluation and adaptation of safety protocols to mitigate the dynamic and multifaceted hazards prevalent in maritime operations (Fan & Yang, 2023; Priyanka & Basaria, 2023).

Implications and Recommendations

The research findings generate multiple practical implications for enhancing K3L risk management. For pilot ladder operations, higher-order engineering controls warrant consideration including permanent access infrastructure, mechanical personnel baskets, standardized lighting, and man-overboard recovery equipment. Administrative controls should be strengthened through detailed risk assessment protocols, mandatory two-person teams, and permit-to-work systems.

Research Limitations

Several limitations warrant acknowledgment. The case study design limits generalizability to other organizations. The cross-sectional nature does not capture longer-term trends. The relatively small participant sample limits statistical power. Reliance on self-reported data introduces potential for social desirability bias. Observational data collection with awareness of study personnel may have introduced observer effects.

CONCLUSION

This comprehensive K3L risk evaluation has systematically documented the complex hazard landscape characterizing vessel clearance operations. The identification of pilot ladder boarding as highest-risk emphasizes the critical importance of prioritizing interventions. The documentation of moderate-level risks across four additional categories reveals cumulative hazard burden. The evaluation of existing control measures revealed well-developed formal frameworks with significant implementation gaps.

The research findings generate actionable recommendations spanning technical interventions, administrative improvements, and cultural transformations. Technology integration offers promising enhancement opportunities. However, technological solutions must be accompanied by organizational safety culture transformation. The ultimate goal is creation of work environments where maritime professionals can perform essential functions safely, healthily, and with dignity. Future research directions include longitudinal studies tracking safety performance over 3-5 years, multi-site comparative studies across different organizational contexts, quantitative epidemiological research on injury incidence rates, intervention research evaluating specific control measures, and investigation of organizational factors influencing safety culture.

ACKNOWLEDGMENTS

CONFLICT OF INTERESTS

The authors declare no conflicts of interest. This study received no specific external funding. PT Pelindo Marine Service provided access for data collection but had no role in research design, analysis, interpretation, or manuscript preparation.

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