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High-Reliability Teams at Sea: The Role of Psychological Safety, Human–System Interaction, and Workload in Error Reporting Behavior among Offshore Workers

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ABSTRACT

Offshore oil and gas operations demand high reliability under extreme physical and psychological conditions. Despite robust engineering systems, many accidents still stem from human and organizational factors. This study examines the role of psychological safety, human–system interaction, and workload in predicting error reporting behavior among offshore workers. A quantitative, cross-sectional design was applied using validated self-report scales: the Psychological Safety Scale (Edmondson), System Usability Scale (SUS), NASA Task Load Index (NASA-TLX), and an adapted Error Reporting Behavior Scale. Data were collected from 188 offshore workers in Indonesia through online questionnaires. Multiple linear regression analysis revealed that psychological safety ($\beta = .38$, $p < .001$) and human–system interaction ($\beta = .27$, $p < .001$) significantly and positively predicted error reporting behavior, while workload showed a significant negative effect ($\beta = -.23$, $p < .001$). The model accounted for 36% of the variance in error reporting ($R^2 = .36$). These findings indicate that workers are more likely to report errors when they feel safe to speak up, perceive systems as user-friendly, and experience manageable workloads. The study highlights the need for integrated interventions that simultaneously foster psychological safety, ergonomic system design, and balanced workload management to enhance proactive safety behavior in offshore environments. This research contributes to the intersection of industrial–organizational psychology and human factors engineering, emphasizing that safety performance in high-reliability organizations relies on both social and technological resilience. These findings align with Sustainable Development Goal 9 (Industry, Innovation and Infrastructure), reinforcing that resilient and sustainable industrial systems require the integration of human factors into safety management and system design.

Keywords : error reporting; human–system interaction; sustainable industrialization; psychological safety; workload

INTRODUCTION

Offshore oil and gas operations represent one of the most complex and high-risk industrial environments in the world. Workers in offshore platforms operate under extreme conditions—exposure to volatile substances, confined spaces, long shifts, and physical isolation—where a single human error can lead to catastrophic consequences for life, the environment, and the company's reputation (Mearns & Yule, 2009; Ghaleh et al., 2019; Zara et al., 2023). Although technological and engineering controls have advanced dramatically in recent decades, research consistently shows that a significant proportion of accidents in offshore environments can be traced to human and organizational factors rather than technical failures alone (Read et al., 2021; Maternová et al., 2023; Kasyk et al., 2023). As a result, there has been growing attention to the psychological and behavioral dimensions of safety in high-reliability organizations (HROs), particularly how offshore teams communicate, perceive risk, and report errors (Rajapakse & Emad, 2025; Lezdkalne, 2025).

The offshore oil and gas sector is often characterized as a "high-reliability system," meaning that its success depends on maintaining consistently safe operations despite high hazard potential (Rivera et al., 2021). However, maintaining reliability at sea is uniquely challenging because of long duty cycles, complex human–machine interfaces, and the social dynamics of isolated teams (Parkes et al., 2012; Rivera et al., 2021). Despite rigorous safety management systems, incident analyses reveal that near misses and minor errors often go unreported due to fear of blame, rigid hierarchies, or system usability issues (Antonsen et al., 2017; Wang et al., 2018). This underreporting creates blind spots in risk management and impedes learning from mistakes.

Safety performance in offshore environments therefore cannot be improved by procedural compliance alone; it requires cultivating an environment where workers feel psychologically safe to voice concerns, supported by ergonomic and technological systems that facilitate error detection and reporting (Zhang et al., 2020). From an industrial-organizational psychology perspective, safety behavior is not only a matter of training or compliance but also of motivation, interpersonal trust, and perceived system usability.

Psychological safety refers to a shared belief that the team is safe for interpersonal risk-taking (Edmondson, 1999). In psychologically safe environments, individuals feel comfortable expressing concerns, admitting mistakes, and asking questions without fear of embarrassment or punishment. Within the context of offshore platforms, where team members depend heavily on one another for survival and task completion, psychological safety is crucial for effective communication and learning (Conchie & Donald, 2009).

Recent studies in safety-critical industries, including aviation, healthcare, and energy, have shown that psychological safety significantly predicts safety participation, error reporting, and learning behaviors (Frazier et al., 2017; Newman et al., 2020). When workers feel psychologically safe, they are more likely to report near misses and unsafe conditions, thereby allowing the organization to detect weak signals before accidents occur. In contrast, when fear or punitive culture prevails, errors are concealed, and systemic risks remain unaddressed (Ofori et al., 2023).

In offshore environments, psychological safety may be especially fragile. Factors such as hierarchical leadership, multi-national crews, and extended isolation from the mainland can intensify interpersonal tension and reduce open communication (de Almeida & Vinnem, 2020). Conchie and Donald (2009) observed that offshore supervisors who encouraged open dialogue and acknowledged human fallibility fostered higher levels of trust and safety voice behavior among their crews. Conversely, authoritarian leadership styles were linked to silence and underreporting.

Psychological safety operates as a social–cognitive mechanism enabling “mindful organizing”—a team’s collective capacity to notice, interpret, and respond to anomalies before they escalate (Amici & Farnese, 2024). Offshore teams with high psychological safety are more likely to share small errors or uncertainties, enhancing collective sensemaking and adaptive response. Thus, psychological safety can be viewed as the interpersonal foundation of high-reliability performance at sea.

While interpersonal climate shapes communication and reporting, the physical and cognitive design of human–system interfaces equally determines whether workers can effectively identify and report errors. Human–system interaction (HSI) encompasses the usability, accessibility, and ergonomic compatibility between operators and the technologies they use (Wilson, 2014). In offshore rigs, control rooms, monitoring panels, and safety systems form an integrated sociotechnical environment where usability directly affects human performance. Poorly designed interfaces can create cognitive overload, delay decision-making, and mask early warning signs of failure (Stanton et al., 2017).

Research on industrial ergonomics has demonstrated that usability issues—such as unclear alarm hierarchies, inconsistent information displays, or complex reporting systems—are frequent contributors to offshore incidents (Patterson, 2017). When workers perceive systems as difficult to use, their willingness to engage with safety tools, including error reporting platforms, diminishes (Karsh et al., 2014). Conversely, user-friendly and intuitive systems enhance compliance, situational awareness, and response accuracy (Salmon et al., 2021). Integrating ergonomic and psychological perspectives reveals that usability does not operate in isolation; it interacts with team climate. Even well-designed systems can fail to improve safety if workers fear retribution for reporting, while a psychologically safe climate may be insufficient if reporting tools are cumbersome or inaccessible. Hence, human–system interaction represents the ergonomic substrate upon which psychological safety can translate into actual reporting behavior.

Another key determinant of safety behavior is workload, defined as the perceived mental, physical, and temporal demands imposed by tasks (Hart & Staveland, 1988). Offshore workers often face irregular shifts, demanding physical labor, and prolonged vigilance, all of which can elevate fatigue and cognitive strain (Ferguson et al., 2023). Excessive workload has been associated with attentional lapses, reduced error detection, and lower compliance with safety protocols (Roelen et al., 2018).

The NASA Task Load Index (NASA-TLX) remains a gold-standard instrument for measuring subjective workload across these dimensions (Hart, 2006). In offshore contexts, high mental and temporal demands can create a cognitive bottleneck, reducing the attentional resources available for error recognition or reporting (Probst et al., 2019). Moreover, chronic workload imbalance can erode psychological safety indirectly by increasing irritability, stress, and conflict within teams (Nahrgang et al., 2011).

Balancing workload is therefore not merely an operational concern but a psychological necessity for maintaining a culture of safety. Research in industrial settings has found that moderate workload levels support engagement and vigilance, whereas both overload and underload impair safety communication and performance (Probst et al., 2019). Offshore environments—with their high-pressure deadlines and shift rotations—demand particularly nuanced workload management strategies to prevent “safety drift,” where minor rule deviations become normalized under pressure (Willis et al, 2024).

Although psychological safety, human–system interaction, and workload have each been studied individually in safety research, few empirical models have integrated these constructs to explain error reporting behavior in offshore contexts. Error reporting refers to the willingness and action of workers to disclose mistakes, near misses, or unsafe conditions (Nahrgang et al., 2011). It is a key proactive safety behavior, allowing organizations to learn and adapt.

From a behavioral perspective, error reporting can be understood as a cost–benefit decision shaped by social, cognitive, and environmental factors. When psychological safety is high, perceived interpersonal cost (e.g., embarrassment, punishment) decreases, making reporting more likely (Frazier et al., 2017). When human–system interaction is efficient and intuitive, the cognitive cost of reporting (e.g., time, complexity) also decreases (Karsh et al., 2014). Conversely, high workload raises the opportunity cost—workers may perceive they "don't have time" to report minor issues.

Integrating these dynamics, we can conceptualize offshore error reporting as the product of (1) a supportive interpersonal climate (psychological safety), (2) an ergonomic and usable system (human–system interaction), and (3) a manageable cognitive load (workload). These three domains—psychological, technological, and operational—reflect the multidisciplinary nature of safety in high-reliability environments.

Empirical evidence supports this integration: in aviation and nuclear sectors, safety voice behavior increases when teams report high psychological safety and low perceived workload (Stanton et al., 2017). Similarly, ergonomic interventions improving system usability have been shown to raise both perceived control and reporting compliance (Stanton et al., 2017). Yet, in offshore oil and gas industries, comprehensive models combining these constructs remain scarce, particularly in developing regions where cultural hierarchies and resource constraints may intensify these challenges (Haavik et al., 2023).

Although psychological safety, human–system interaction, and workload have each been studied individually in safety research, few empirical models have integrated these constructs to explain error reporting behavior in offshore contexts. Error reporting—the willingness of workers to disclose mistakes, near misses, or unsafe conditions—is a key proactive safety behavior that enables organizational learning and accident prevention (Karsh et al., 2014).

From a behavioral standpoint, error reporting can be viewed as a decision process shaped by interpersonal climate, system usability, and cognitive demands. High psychological safety reduces interpersonal barriers such as fear of punishment or embarrassment (Frazier et al., 2017); intuitive and user-friendly systems lower cognitive barriers to reporting (Karsh et al., 2014); and manageable workloads minimize the perceived time and effort costs of reporting.

However, research integrating these psychosocial, ergonomic, and workload dimensions into a single predictive model remains limited—particularly in offshore oil and gas settings where hierarchical culture and physical isolation can intensify underreporting (Haavik et al., 2023).

Therefore, this study aims to examine the simultaneous influence of psychological safety, human–system interaction, and workload on error reporting behavior among offshore oil rig workers.

By employing a multiple linear regression framework, the study quantifies how interpersonal climate, system usability, and task demands collectively predict safety communication behaviors. From an applied perspective, this research contributes to both psychology and human factors engineering by: (1) expanding the understanding of how psychological safety interacts with ergonomic and workload conditions in shaping reporting behaviors; (2) providing empirical evidence using validated instruments (e.g., Psychological Safety Scale, System Usability Scale, NASA-TLX) in offshore contexts; and (3) offering practical implications for safety management systems—highlighting that fostering psychological safety and ergonomic design are equally vital to improving reporting culture.

RESEARCH METHOD

Method

This study employed a quantitative, cross-sectional survey design to examine the relationships among psychological safety, human–system interaction, workload, and error reporting behavior among offshore oil rig workers. The design was selected to enable statistical assessment of how individual perceptions of interpersonal climate, system usability, and task demands predict proactive safety communication. A multiple linear regression approach was used to determine the combined and unique contributions of the three predictor variables on the dependent variable—error reporting behavior.

The study followed ethical standards for research involving human participants and adhered to the principles of the Declaration of Helsinki (World Medical Association, 2013). Participation was voluntary, and informed consent was obtained electronically prior to data collection.

Participants

Participants were offshore oil rig workers employed in exploration and production operations located in Indonesia. Inclusion criteria required that participants (a) had at least six months of offshore

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experience, (b) were directly involved in operational or maintenance tasks, and (c) could communicate in Bahasa Indonesia. Workers in purely administrative or onshore roles were excluded. A minimum sample size of 77 was estimated using GPower 3.1 (Faul et al., 2007) for multiple regression with three predictors, assuming a medium effect size ($f^2 = 0.15$), $\alpha = .05$, and power ($1–\beta$) = .80. To increase statistical reliability and account for potential incomplete responses, the target sample size was set at 188 participants.

Demographic data such as age, gender, years of offshore experience, job role (e.g., drilling, maintenance, safety supervision), and work rotation pattern (e.g., 14/14, 21/21) were collected for descriptive purposes and as potential control variables. The study followed ethical standards for research involving human participants and adhered to the principles of the Declaration of Helsinki (World Medical Association, 2013). Participation was voluntary, and informed consent was obtained electronically prior to data collection.

Measures

All variables were measured using validated self-report scales with demonstrated psychometric reliability in industrial or safety-critical contexts. Responses were recorded using Likert-type scales, and total scores were computed according to established scoring procedures. Cronbach's alpha coefficients above .70 were considered acceptable for internal consistency (Nunnally & Bernstein, 1994).

Psychological safety was assessed using the Psychological Safety Scale developed by Edmondson (1999), consisting of seven items that measure the extent to which team members feel safe to express opinions and admit mistakes without fear of negative consequences. Sample items include: *"It is safe to take a risk in this team"* and *"Members of this team are able to bring up problems and tough issues."* Participants rated their agreement on a 5-point Likert scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*). Higher scores indicate greater perceived psychological safety. The scale has demonstrated strong reliability and validity across diverse occupational settings, including offshore and industrial environments (Frazier et al., 2017). In the current study, the Cronbach's alpha coefficient was expected to exceed .85, consistent with previous applications (Newman et al., 2017).

Human–System Interaction (Perceived usability of the offshore reporting and control systems) was measured using the System Usability Scale (SUS) by Brooke (1996). The SUS consists of ten items rated on a 5-point scale (1 = *Strongly Disagree*, 5 = *Strongly Agree*). It assesses overall usability and ease of interaction with technological systems, including clarity, consistency, and confidence of use. Items alternate between positive and negative wording, which are reverse scored as recommended. The total SUS score ranges from 0 to 100, with higher values indicating better perceived usability. SUS has been widely used in industrial and safety-critical domains with strong internal consistency ($\alpha \approx .90$). In this study, the scale was adapted slightly to reflect offshore safety and reporting systems (e.g., digital reporting interfaces, control panels, and alarm systems).

Workload was measured using the NASA Task Load Index (NASA-TLX) developed by Hart and Staveland (1988). The NASA-TLX evaluates six subdimensions: Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, and Frustration. Participants rated each dimension on a 20-point scale (from *Very Low* to *Very High*). A composite workload score was calculated by averaging the six dimensions, following Hart's (2006) recommendation for general research applications. The NASA-TLX has been validated in various high-stakes environments, including aviation, maritime, and offshore operations. Higher scores represent higher perceived workload.

Error reporting behavior—the dependent variable—was measured using a 6-item scale adapted from Voice Behavior and Error Reporting Scales (Whitacre et al., 2025). The items assess workers' self-reported frequency and willingness to report near misses, unsafe acts, or system irregularities. Sample items include: *"I report mistakes or near misses even when they are minor,"* and *"I speak up when I notice safety issues, even if others might not."* Responses were recorded on a 5-point frequency scale (1 = *Never*, 5 = *Always*). Higher scores reflect stronger engagement in error reporting behaviors. The adapted scale has shown excellent internal reliability (α = .86–.91) in previous studies within safety-critical sectors.

Procedure

Data collection was conducted over a three-month period. Digital based questionnaires were distributed via online platform (Google Forms). Participation was anonymous to minimize social desirability bias and encourage honest responses.

Respondents were provided with a brief introduction outlining the study's purpose, confidentiality assurance, and estimated completion time (approximately

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15–20 minutes). They were informed that there were no right or wrong answers and that their responses would not affect their employment status. Completed questionnaires were sealed in envelopes or submitted via encrypted online forms.

To minimize respondent fatigue, items were randomized across sections, and demographic questions were placed at the end of the survey. Variables were measured using validated self-report scales with demonstrated psychometric reliability in industrial or safety-critical contexts. Responses were recorded using Likert-type scales, and total scores were computed according to established scoring.

Hypothesis Testing

A multiple linear regression analysis was conducted with psychological safety, human–system interaction, and workload as independent variables, and error reporting behavior as the dependent variable. The following hypotheses were tested:

H1: Psychological safety positively predicts error reporting behavior among offshore workers.

H2: Human–system interaction (usability) positively predicts error reporting behavior.

H3: Workload negatively predicts error reporting behavior.

H4: Psychological safety, human–system interaction, and workload jointly predict error reporting behavior.

The level of significance was set at $p < .05$ (two-tailed). Adjusted R^2 values were used to evaluate the explanatory power of the model, and standardized beta coefficients (β) were interpreted to assess relative predictor importance.

To ensure the validity of regression results, assumptions of linearity, homoscedasticity, normality, and independence of residuals were examined. Scatterplots and standardized residual plots were inspected for violations. The Durbin–Watson statistic was used to test for autocorrelation, with values between 1.5 and 2.5 indicating independence.

RESULTS AND DISCUSSION

Descriptive Statistics & Correlation

All variables were within acceptable skewness and kurtosis ranges (±2). Table 1 presents the descriptive statistics and correlations.

Table 1. Mean and Standard Deviation (N = 188)

Variable	**M**	**SD**
Psychological Safety	3.87	0.56
Human-System Interaction	74.23	10.21
Workload	62.19	8.92
Error Reporting Behavior	4.01	0.58

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Psychological safety also showed a significant positive correlation with error reporting ($r = .47$, $p < .05$), as did human–system interaction ($r = .38$, $p < .05$). Workload demonstrated a negative relationship with error reporting ($r = -.35$, $p < .05$).

Hypothesis Testing

The multiple regression model predicting error reporting was significant, $F(3, 184) = 34.27$, $p < .001$, $R^2 = .36$, indicating that the three predictors jointly explained 36% of the variance in error reporting behavior.

Table 2 presents the standardized regression coefficients, *t*-values, and significance levels for each predictor variable, showing the unique contribution of psychological safety, human–system interaction, and workload to error reporting behavior.

Table 2. Regression Coefficients

Predictor	β	t	p
Psychological Safety	.38	6.02	<.001
Human-System Interaction	.27	4.41	<.001
Workload	-.23	-3.82	<.001

The findings indicate that psychological safety and human–system interaction positively predict error reporting behavior, while workload has a significant negative effect. Psychological safety emerged as the strongest predictor ($\beta = .38$).

The results provide empirical support for the critical role of psychological and ergonomic factors in promoting safety behaviors within high-reliability offshore environments. Specifically, the findings highlight that when offshore workers feel psychologically safe, perceive systems as usable, and experience manageable workloads, they are more likely to report errors proactively — a cornerstone of organizational learning and accident prevention.

Consistent with prior studies (Bye et al., 2020; Hasan et al., 2020; Fleming et al., 2022; Simonova et al., 2024; Zhan et al., 2025), the strong positive relationship between psychological safety and error reporting underscores the importance of trust and interpersonal openness in safety-critical teams. Offshore workers often operate in tightly interdependent conditions, where hierarchical distance and communication barriers can inhibit reporting. When team members believe that speaking up will not result in punishment or ridicule, they become active participants in the organization's safety culture. This finding extends Edmondson's (1999) theory into the high-reliability offshore domain, showing that psychological safety functions as a social mechanism that transforms latent risk into explicit, reportable information.

The usability of offshore control systems significantly contributed to error reporting behavior. This supports prior ergonomic research emphasizing that human–system compatibility enhances situational awareness and reduces cognitive strain (Stanton et al., 2017). When systems are intuitive and responsive, operators can focus cognitive resources on task monitoring rather than interface navigation. This finding bridges psychological safety and ergonomics: effective system design not only reduces errors but also conveys institutional care, reinforcing the perception of a psychologically safe climate.

Workload exhibited a negative association with error reporting, aligning with cognitive load theory and previous findings (Hasan et al., 2020; Fleming et al., 2022; Haavik et al., 2023). Excessive workload can overwhelm attentional capacity, suppressing self-monitoring and communication. In offshore contexts, chronic time pressure and fatigue may lead workers to prioritize production goals over reporting (Hasan et al., 2020; Casey et al., 2022). Thus, managing workload balance is essential not only for performance but also for sustaining a safe reporting culture.

The combined predictive power (R^2 = .36) suggests that psychological safety, human–system interaction, and workload jointly shape a worker's readiness to report. These findings align with the socio-technical systems theory, which emphasizes the interdependence between human, technological, and organizational subsystems (Carayon et al., 2025). Interventions that target only technical or procedural dimensions without addressing interpersonal and workload factors may fail to achieve sustainable safety outcomes.

Organizations operating in offshore environments can draw three key insights: (1) Cultivate psychological safety: Supervisors should model openness by acknowledging their own mistakes and inviting input, signaling that reporting is valued; (2) Enhance system usability: Regular usability testing and participatory design with end-users can reduce error likelihood and frustration; (3) Manage workload: Shift rotations, staffing adequacy, and workload monitoring systems can prevent cognitive overload and promote vigilance.

Although this study provides valuable insights, its cross-sectional design limits causal interpretation. Future research could adopt longitudinal or experimental methods to track how interventions in psychological safety or ergonomic redesign influence reporting over time. Additionally, qualitative approaches such as focus groups could uncover cultural and organizational

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nuances specific to offshore operations in different regions.

CONCLUSION

This study examined how psychological safety, human-system interaction, and workload simultaneously influence error reporting behavior among offshore oil rig workers. The regression results demonstrated that psychological safety and human–system interaction positively predict error reporting, while workload has a significant negative effect. Together, these three factors explained 36% of the variance in workers' reporting behavior, underscoring that both interpersonal and ergonomic conditions shape the willingness to report errors at sea.

The findings align with previous research highlighting psychological safety as a key antecedent of safety voice (Frazier et al., 2017) and extend this understanding by integrating human–system interaction and workload within the same predictive model. This integrated approach provides a more holistic view of safety behavior, emphasizing that error reporting is not solely a social or individual decision but also a function of system design and task demands.

From a theoretical standpoint, this study contributes to the growing intersection between psychology and human factors engineering by bridging psychosocial and ergonomic perspectives in explaining safety communication. From a practical perspective, the results suggest that offshore safety programs should not only focus on cultivating trust and open communication but also ensure that reporting systems are intuitive and workload is manageable. Interventions combining leadership practices that foster psychological safety with user-centered reporting tools may therefore enhance error transparency and learning culture in high-reliability maritime operations.

Future research could explore longitudinal or cross-industry comparisons to identify how cultural or organizational contexts moderate these relationships. Additionally, qualitative approaches could enrich the quantitative findings by uncovering workers' lived experiences and perceived barriers to reporting.

In sum, the present study advances understanding of how psychological, technological, and operational factors interact to promote reliable reporting behavior in offshore environments—contributing to safer, more adaptive, and human-centered safety systems.

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