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The role of ISO 31000 risk management in enhancing HSE and project performance: evidence from oil and gas construction projects

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Abstract
Using a survey, 152 professionals involved in Indonesian oil and gas pipeline projects were approached to examine how different elements of ISO 31000 risk management (Context and Criteria (IC), Identify and Analyse (IA), Evaluate and Treat (ET), and Communication (CM)) affect both Health, Safety, and Environment (HSE) performance and overall project outcomes. The data analysis was conducted using Partial Least Squares Structural Equation Modelling (PLS-SEM). The results show that Context and Criteria have a strong positive influence on HSE performance (β = 0.55, p < 0.001), as well as project performance (β = 0.90, p < 0.001). Evaluate and Treat also significantly boosts HSE (β = 0.65, p < 0.001). In contrast, Identify and Analyse, Communication, and even HSE performance do not appear to have a significant direct impact on project outcomes. The model accounts for a substantial proportion of the variance in both HSE (R²_HP = 0.64) and project performance (R²_PP = 0.71). Early-stage risk contextualisation and active risk treatment are far more influential than merely identifying or communicating risks, especially in the high-risk setting of oil and gas construction. For project owners, contractors, and regulators, the lesson is clear: prioritise early risk framing, allocate concrete resources for treatment, and incorporate risk criteria into contracts to achieve better safety and more reliable project delivery.

Keywords:
Health and Safety Environment;
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INTRODUCTION

Oil and gas construction projects require significant investments, push technical boundaries, and involve considerable health, safety, and environmental risks. When crews weld pipelines, excavate trenches, perform hydrostatic testing, or manage commissioning, the dangers multiply, and if risks aren't properly managed, the consequences can be serious: accidents, environmental damage, and expensive project delays. In this industry, risk management isn't optional—it's crucial for safeguarding people and maintaining project progress [1][2]. Previous studies in Indonesia have shown that most research on risk management in oil and gas (O&G) construction projects has centred on traditional safety measures, such as the utilisation of personal protective equipment (PPE) or hazard identification methods, lacking a holistic framework for managing project risks [3][4].

ISO 31000 defines risk management as a structured and systematic approach to identifying, analysing, evaluating, and mitigating risks. Using ISO 31000 in construction projects has been shown to enhance safety, ensure regulatory compliance, and increase efficiency [5][6]. Nonetheless, empirical evidence on the implementation of ISO 31000 in Indonesian oil and gas projects remains scarce. Most previous research focuses on risk management in the construction of buildings or roads [6, 7, 8, 9]. On the other hand, pipeline construction projects, which present unique risks such as welding, trenching, coating, hydrostatic testing, and tie-in operations, haven't been studied as extensively.

ISO 31000 provides a comprehensive framework for organizational risk management. However, most existing research tends to focus on just one aspect or outcome, often emphasizing safety alone. Additionally, studies usually center on general construction or infrastructure projects, not specifically on oil and gas pipeline projects, which present unique technical and regulatory hurdles. Previous studies rarely assess all ISO 31000 processes together, nor do they explore how these processes collectively influence both HSE and project performance. This type of holistic, model-driven evidence is especially limited in emerging economies, where local context and institutional factors are highly relevant.

This gap is significant because pipeline and refinery projects face not only the usual construction risks but also operational risks, environmental concerns, and regulatory pressures. Few studies examine how the four ISO 31000 dimensions: Context and Criteria (IC), Identify and Analyse (IA), Evaluate and Treat (ET), and Communication (CM), impact both HSE Performance (HP) and Project Performance (PP) in these situations.

Three gaps that prompt this study are the clarity of antecedent processes, the pathways from processes to outcomes, and evidence related to oil and gas projects. There is insufficient evidence to demonstrate that the four ISO components collectively influence health, safety (HP), and project performance (PP), nor to establish their individual effects. This is especially true for construction management (CM), as it is a key factor in learning and stabilising performance. Few empirical, model-based studies focus on pipeline construction, particularly in emerging markets where cultural and institutional factors vary. These studies would address complex tasks such as welding, trenching, coating, hydrotesting, and tie-ins.

This research proposes and evaluates an organisation-process-outcome model for ISO 31000 within the oil and gas construction sector to address these gaps. Additionally, few comprehensive studies link ISO 31000-based risk management practices to measurable project outcomes using rigorous analytical methods. The lack of real-world evidence makes it difficult to determine the extent to which ISO 31000 reduces health, safety, and environment (HSE)- related accidents in the oil and gas construction industry. It is essential to address this gap, as poor risk management can lead to accidents, environmental damage, and significant project delays. This study advances the field by evaluating an integrated organization–process–outcome model of ISO 31000 within Indonesian oil and gas pipeline construction. Rather than isolating a single risk management practice or outcome, we examine four ISO 31000 dimensions: Context and Criteria, Identify and Analyze, Evaluate and Treat, and Communication, and track their actual impact on both HSE and project performance using PLS-SEM.

This study aims to address this shortcoming by empirically testing 9 hypotheses linking ISO 31000 dimensions to HSE and project performance in oil and gas construction projects. The novelty of this study lies in the specification and empirical validation of a comprehensive organisation–process–outcome model for ISO 31000 in oil and gas (O&G) pipeline construction. Rather than testing isolated practices or single outcomes, we concurrently model how the four ISO 31000 processes and their cascading effects on both HSE and project performance yield a 9-hypothesis framework, validated with pilot-tested measures and PLS-SEM evidence. This study is distinctive because it examines both safety and performance outcomes in a high-risk industrial environment. This provides new insights into how risk management standards can enhance project delivery. The objectives of this research are investigated how ISO 31000 risk management dimensions affect HSE performance. assess their impact on project performance, and determine whether HSE performance mediates the relationship between ISO 31000 practices and project performance in oil and gas construction.

This research employs a quantitative methods approach and validates its findings through Focus Group Discussions (FGDs) with experts in the field. The Structural Equation Modelling-Partial Least Squares (SEM-PLS) was applied to develop the framework shown in Figure 1, which represents the hypothesised four ISO 31000 processes (IC, IA, ET, CM) that predict HSE Performance (HP) and Project Performance

(PP). The model operationalises nine hypotheses (H1–H9) and motivates the PLS-SEM analysis.

Hypothesis 1 (H1) arises from a precise delineation of context and risk criteria that synchronises controls with actual risk exposures, consequently enhancing HSE performance [9][10]. Evidence from construction indicates that structured management baselines are associated with improved safety outcomes [11][12]. Systematic reviews suggest that strong contextualization enhances hazard recognition and the prioritisation of control measures [13][14]. Consequently, improved ISO 31000 context and criteria are expected to positively affect HSE performance [12][15] (H1: IC → HP). Empirical studies have linked structured management baselines to improved coordination and performance in construction [10], [13]. By aligning stakeholders on acceptable risk and decision thresholds, projects experience fewer disruptions [12][13]. Therefore, a stronger ISO 31000 context and criteria should enable projects to perform better [16][17] (H2: IC → PP).

In-depth risk identification and analysis help create targeted interventions that reduce incidents and exposures [9][11]. Research using PLS-SEM models in the oil and gas sector reveals that improved identification and analysis lead to better safety outcomes [18][19]. Studies on interventions confirm that data-driven analysis enhances HSE outcomes in process industries [8]. Therefore, ISO 31000 Identify and Analyse should positively affect HSE performance [12][20] (H3: IA → HP).

Nonetheless, the prompt identification and assessment of risks facilitate preventive measures that safeguard temporal and fiscal performance [9][21]. Evidence indicates that risk identification and monitoring are critical indicators of project success [10][12].

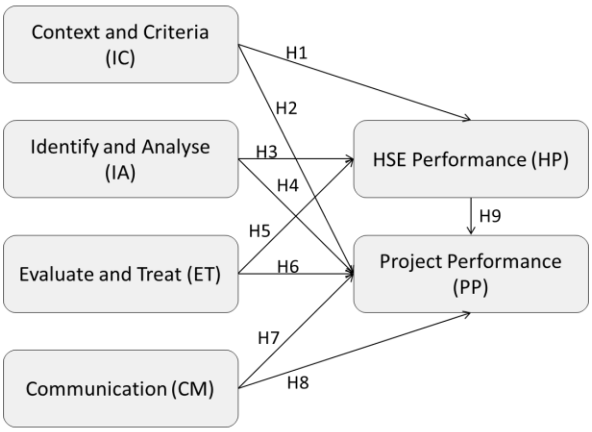

Figure 1. Conceptual ISO 31000 Performance Model

A thorough hazard analysis reduces the frequency of rework and claims on construction projects [11][13]. So, ISO 31000 Identify and Analyse should have a positive effect on the project's overall performance [16][20] (H4: IA → PP).

Practical evaluation and treatment select controls that most effectively reduce risk. This directly improves HSE [9][10]. Research in the construction and process sectors shows that well-implemented interventions lower incident rates and improve safety perceptions [11][15]. Managerial commitment to treatment ensures proper implementation and ongoing improvement [3][9]. Therefore, ISO 31000 Evaluate and Treat is expected to have a positive impact on HSE performance [6][12] (H5: ET → HP). Strong evaluation and treatment make controls more cost-effective, which leads to better outcomes in terms of cost, time, and quality [9][10]. Research indicates that improved project KPIs in construction are associated with effective risk responses and interventions [11][21]. Integrated treatment portfolios also facilitate recovery from successive disruptions [16][17]. Therefore, ISO 31000 Evaluate and Treat should have a positive impact on a project's success [12][16] (H6: ET → PP).

Communication, monitoring, and documentation support learning and corrective action cycles that prevent incidents from happening again [9][10]. The use of leading indicators and active monitoring is associated with improved safety outcomes in construction [12][19]. Reviews emphasise that feedback loops that occur repeatedly are essential for maintaining effective control [9][22]. ISO 31000 communication and monitoring should positively impact HSE performance [12][23] (H7: CM ➔ HP). Continuous communication and monitoring help create a level playing field by ensuring everyone has the same information. This enables quick corrective actions that maintain high delivery performance [9][10]. Clear recordings improve coordination and reduce disputes among stakeholders [13][24]. Therefore, ISO 31000 communication, monitoring, and recording should help projects perform better [12][16] (H8: CM → PP).

Better HSE performance results in fewer disruptions, absences, and stoppages due to incidents, thereby boosting productivity and leading to more reliable schedules [13][15]. Improved safety leads to higher-quality outcomes and a reduced need for rework [18][19]. Research indicates a correlation between adequate safety and management practices and improved project KPIs [12][21]. As a result, improved HSE performance is expected to positively affect overall project performance in construction [12][16] (H9: HP → PP).

This research paper is divided into five sections: Section 2 describes the methodology, Section 3 presents the results, Section 4 discusses the implications, and Section 5 concludes with limitations and future work.

METHOD

This section presents the primary analytical methods, sampling details, instrument specifications, and instrument quality assurance.

Methods

This study utilised a quantitative, cross-sectional survey to empirically examine the relationships among the four ISO 31000 risk-management components: context & criteria (IC), identify & analyse (IA), evaluate & treat (ET), and communication (CM), and their impact on HSE performance (HP) and project performance (PP). This method was employed, an approach well-suited to analysing latent constructs and developing predictive models in the complex environment of construction projects. A survey design was selected to obtain standardised perceptions and practices from a sufficiently large cohort of practitioners, facilitating variance-based Structural Equation Modelling (PLS-SEM) for theoretical testing and prediction. PLS-SEM was chosen over covariance-based SEM due to moderate sample size, exploratory focus, and the typically non-normal data found in this sector.

Population, Sampling, and Respondents

The target population consisted of professionals engaged in the construction of oil and gas (O&G) pipelines, including owners/clients, EPC contractors, and supervising consultants. Purposive sampling was employed to ensure that respondents had relevant experience in project risk management and HSE practices. The inclusion criteria were: (i) a current or recent role (≤3 years) on oil and gas pipeline projects; (ii) involvement in project, health and safety, or risk-related functions (e.g., project manager, engineer, construction supervisor, inspector, safety officer); and (iii) a willingness to participate. Data was collected online from July to August 2025, with the survey distributed through professional networks and project contacts. Of 170 surveys sent, 152 were returned valid, a response rate of 89.4%. Participation was voluntary, anonymity was maintained, and all participants provided informed consent prior to taking part. There were 152 usable responses in the final dataset, which meets the standard adequacy rules for PLS-SEM (the 10-times rule and typical power recommendations for medium effects). This gives the proposed model acceptable statistical power.

Instrument Development

The questionnaire operationalised the latent variables IC, IA, ET, CM, HP, and PP using reflective indicators tailored to the O&G pipeline context. A five-point Likert scale was used to measure the items, with one indicating "strongly disagree" and five indicating "strongly agree." Expert review (by academics and senior practitioners) was used to ensure that each construct was clear, relevant, and comprehensive. After receiving feedback from experts, we made minor adjustments to the wording to enhance clarity and improve its face validity.

Pilot Study and Measurement Quality

A pilot study involving 30 participants was conducted before full deployment to evaluate item performance and initial psychometric properties. The results indicated that all variables satisfied standard psychometric criteria: item loadings achieved the recommended thresholds (≥0.70) or were preserved with theoretical justification; Composite Reliability (CR) surpassed 0.70 for all constructs; and Average Variance Extracted (AVE) exceeded 0.50, thereby affirming convergent validity and construct reliability, as detailed in Tables 1 and 2. Table 1 presents the reliability test (Cronbach's Alpha) for the constructs' internal consistency. All constructs exceed the 0.70 threshold (e.g., IC=0.887; IA=0.952; ET=0.949; CM=0.954; HP=0.944; PP=0.940), indicating strong reliability before structural analysis. Table 2 presents the validity test (corrected item–total correlation) — item–construct relationships. Corrected item–total correlations are high across indicators (e.g., IC1 = 0.784 to IC4 = 0.922; IA1 = 0.932 to IA4 = 0.947), supporting convergent validity and justifying the retention of all items. The pilot study also demonstrated that the instrument was precise and required an appropriate amount of time to complete, making it unnecessary to modify its structure prior to the main study.

Analysis Strategy

The structural equation modelling using SmartPLS 4.0. For the measurement model, adhered to established standards: indicator loadings of at least 0.70, Composite Reliability of 0.70 or higher, Average Variance Extracted above 0.50, HTMT below 0.85, and VIF under 3.3. Model fit was evaluated using SRMR, with values below 0.08 deemed acceptable. There were two steps to the PLS-SEM analysis (SmartPLS) [26]. The first step is to examine the measurement model, which encompasses indicator reliability (outer loadings), internal consistency (Cronbach's alpha and Composite Reliability, CR), and convergent validity (Average Variance Extracted, AVE) [25]. Discriminant validity was evaluated using the Fornell–Larcker criteria and the HTMT ratio, with an acceptable threshold of HTMT < 0.85–0.90. Use the inner and outer Variance Inflation Factors (VIFs) to assess multicollinearity. The best values are below five, and the safest values are below 3.3.

The second phase involved evaluating the structural model, which estimated path coefficients and their significance via bootstrapping (e.g., 5,000 resamples; two-tailed α = 0.05). Coefficient of determination (R^2) to assess explained variation in endogenous constructs (HP, PP, and ISO 31000 process constructs, when relevant).

Table 1. Reliability Test (Cronbach's Alpha)

Variables	Indicators	Cronbach's Alpha
IC	IC1, IC2, IC3, IC4	0.887
IA	IA1, IA2, IA3, IA4	0.952
ET	ET1, ET2, ET3, ET4	0.949
CM	CM1, CM2, CM3, CM4	0.954
HP	HP1, HP2, HP3, HP4	0.944
PP	PP1, PP2, PP3, PP4	0.940

Table 2. Validity Test (Corrected Item-Total Correlation)

Variables	Indicators	Corrected Item-Total Correlation
IC	IC1	0.784
	IC2	0.885
	IC3	0.873
	IC4	0.922
IA	IA1	0.932
	IA2	0.921
	IA3	0.921
	IA4	0.947
ET	ET1	0.917
	ET2	0.882
	ET3	0.949
	ET4	0.911
CM	CM1	0.924
	CM2	0.965
	CM3	0.921
	CM4	0.905
HP	HP1	0.953
	HP2	0.943
	HP3	0.872
	HP4	0.923
PP	PP1	0.936
	PP2	0.915
	PP3	0.923
	PP4	0.877

Blindfolding is used to determine the predictive relevance (Q^2) of endogenous constructs, thereby testing their out-of-sample predictive power. If Q^2 is greater than 0, it means that the construct is relevant. Effect sizes (f^2) for particular pathways were informative, and model fit diagnostics (e.g., SRMR, employed as a descriptive metric in PLS) were also considered. The analysis of the results included (i) measurement-model statistics (loadings, CR, AVE, HTMT), (ii) structural-model outcomes (standardised path coefficients, t-values, p-values), R^2, and Q^2, and (iii) hypothesis determinations (supported/not supported). The study examines the interconnections among the ISO 31000 process components (IC, IA, ET, CM) and their effects on Health, Safety, and Environmental Performance (HP) and Project Performance (PP).

RESULTS

This section presents the respondents' demographic characteristics, the SEM-PLS model analysis, and the discussion.

Respondents Profile

Table 3 presents the profiles of the individuals who responded to the questions. The demographic analysis of 152 respondents provides an extensive overview of their professional backgrounds and project contexts in the oil and gas construction industry. Most respondents are engineers and site supervisors, suggesting that those who work on projects tend to possess technical skills. A smaller percentage comprises project managers, safety officers, and other professionals who provide support. This indicates that the respondents are a diverse yet technically focused group.

The answers regarding work experience on oil and gas construction projects are relatively evenly distributed. A large proportion of respondents reported more than 15 years of experience, suggesting that the sample consisted of many highly experienced professionals. At the same time, there are also large groups of respondents with 6–10 years and 11–15 years of experience. This shows that the study includes both experienced and mid-level practitioners. This makes the collected perceptions more reliable because they reflect the views of people at different stages of their careers.

Most of the respondents are working on onshore projects, primarily pipeline and refinery work. A smaller number are working on offshore projects.

Table 3. Respondents Demographic Profile

Position	Frequency	Percentage
Engineer	88	57.89
Job Supervisor	31	20.39
Job Owner	21	13.82
Researcher	4	2.63
HSE Team	4	2.63
EPC Contractor	4	2.63
Length of experience in oil and gas construction projects	**Frequency**	**Percentage**
> 15 Years	72	47.37
11 - 15 Years	30	19.74
2 - 5 Years	23	15.13
< 2 Years	15	9.87
6 - 10 Years	12	7.89
Project Type	**Frequency**	**Percentage**
Onshore	144	94.74
Offshore	8	5.26
Current Project Phase	**Frequency**	**Percentage**
Construction	120	78.95
Commissioning	27	17.76
Pre-commissioning	5	3.29
Average Monthly Working Hours on Project (Estimated)	**Frequency**	**Percentage**
121 – 160 hours/month	38	25
> 200 hours/month	34	22.37
161 – 200 hours/month	34	22.37
≤ 80 hours/month	23	15.13
81 – 120 hours/month	23	15.13

This distribution makes sense because most oil and gas infrastructure development in Indonesia occurs on land. Most respondents to the question are engaged in the construction and commissioning phases of the current project. These phases are typically high-risk and require substantial resources.

Lastly, most respondents reported working more than 200 hours per month, followed by those who reported working 81 to 120 hours per month. This finding suggests that oil and gas construction projects entail extensive work and tight schedules, which can increase fatigue and heighten risk exposure. Overall, the demographic profile indicates that the respondents come from diverse roles, experience levels, and project contexts, which enhances the reliability of the study's findings.

Measurement Model Evaluation (Outer Model)

The Average Variance Extracted (AVE) is a measure of convergent validity. Hair et al. (2021) state that an AVE above 0.50 indicates that a construct accounts for more than 50% of the variance in its indicators. All constructs in this study met this requirement: IC (0.62), IA (0.60), ET (0.61), CM (0.59), HP (0.65), and PP (0.64). These results confirm that the indicators adequately represent their corresponding latent constructs.

Cronbach's Alpha and Composite Reliability (CR) were used to check for internal consistency. Both measures exceeded the suggested threshold of 0.70. The Cronbach’s Alpha values ranged from 0.80 to 0.87, while the Composite Reliability values ranged from 0.86 to 0.91. These results indicate that the constructs are reliable and consistently assess the intended concepts. Table 4 presents the Outer Model Summary (Loadings, CR, AVE) and the Measurement quality overview. Composite Reliability ranges roughly 0.86–0.91, and AVE ~0.59–0.65, confirming internal consistency and convergent validity; HP and PP show the highest AVE values (0.65 and 0.64).

Discriminant validity was established by ensuring that the square root of each construct's Average Variance Extracted (AVE) was greater than its correlations with other constructs, following the Fornell–Larcker criterion. This was not explicitly detailed in the frequency tables. Cross-loading analysis also indicated that each indicator loaded more heavily on the associated construct than on any other construct. This confirms that each construct is distinct in its practical application. The overall results of the outer model show that the measurement model is both valid and reliable. The indicators demonstrate good convergent validity, the constructs exhibit strong reliability, and discriminant validity is established.

Therefore, the model is robust and suitable for further analysis of the inner model, such as testing the proposed links between ISO 31000 dimensions, HSE performance, and project performance in oil and gas construction projects.

Table 4. Outer Loading

Construct	Cronbach's Alpha	Composite Reliability	AVE
IC	0.85	0.89	0.62
IA	0.82	0.87	0.60
ET	0.83	0.88	0.61
CM	0.80	0.86	0.59
HP	0.87	0.91	0.65
PP	0.86	0.90	0.64

Inner Model Analysis

Blindfolding was used to assess the model's predictive relevance (Q^2), which indicates how well exogenous constructs predict endogenous constructs. Hair et al. [27] assert that Q^2 values exceeding 0 indicate predictive relevance and establish thresholds at 0.02 (small), 0.15 (medium), and 0.35 (large).

Table 5 presents R^2 and Q^2 Values — measures of explanatory and predictive power. R^2 indicates substantial explained variance (HP=0.64; PP=0.71). Blindfolding Q^2 evidences enormous predictive relevance (HP=0.638; PP=0.698), supporting the model's predictive capability for both safety and project outcomes. The findings indicate that HSE Performance (HP): Q^2 = 0.638, classified as significant predictive relevance. This shows that the ISO 31000 constructs (IC, IA, ET, CM) are effective in predicting HSE outcomes in oil and gas projects. Project Performance (PP): Q^2 = 0.698, indicating that it has considerable predictive power. This means that ISO 31000 constructs and HSE performance work together to effectively explain project outcomes. These results demonstrate that the model is robust and performs very well in predicting both safety and project-related outcomes. Five thousand subsamples were used to test the significance of direct and indirect hypotheses.

Table 6 presents the results of hypothesis testing. Supported paths: IC→HP (β=0.55, p<0.001), IC→PP (β=0.90, p<0.001), ET→HP (β=0.65, p<0.001). Non-significant paths: IA→HP/PP, CM→HP/PP, and HP→PP, suggesting that identification and communication require stronger integration with execution, and that HSE gains did not directly translate to PP in this sample.

Figure 2 presents the Structural Model, PLS-SEM results summarising significant and non-significant paths. Significant positive effects are observed for IC→HP, ET→HP, and IC→PP, while IA→HP/PP, CM→HP/PP, and HP→PP are non-significant. This pattern suggests substantial leverage in early contextualization (IC) and treatment execution (ET) for safety, with limited direct transmission from identification and communication to project KPIs. HSE performance (HP) affects project performance (PP) by mediating the effects of ISO 31000 constructs (IC, IA, ET, CM). Nonetheless, because H9 (HP → PP) is not significant, the indirect effects via HP are also insignificant. This indicates that while IC and ET enhance HSE outcomes, these enhancements do not correlate with increased project performance in the examined sample.

Table 5. Coefficient of Determination (R^2) and Predictive Relevance (Q^2)

Construct	R^2	Q^2
HP	0.64	0.638
PP	0.71	0.698

Table 6. Direct Hypotheses

	Path	β	t-value	p-value	Result
H1	IC → HP	0.55	7.09	<0.001	Supported
H2	IC → PP	0.90	16.60	<0.001	Supported
H3	IA → HP	0.13	1.87	>0.05	Not Supported
H4	IA → PP	-0.23	1.90	>0.05	Not Supported
H5	ET → HP	0.65	7.34	<0.001	Supported
H6	ET → PP	0.00	0.03	>0.05	Not Supported
H7	CM → HP	0.01	0.10	>0.05	Not Supported
H8	CM → PP	-0.06	0.54	>0.05	Not Supported
H9	HP → PP	-0.09	1.77	>0.05	Not Supported

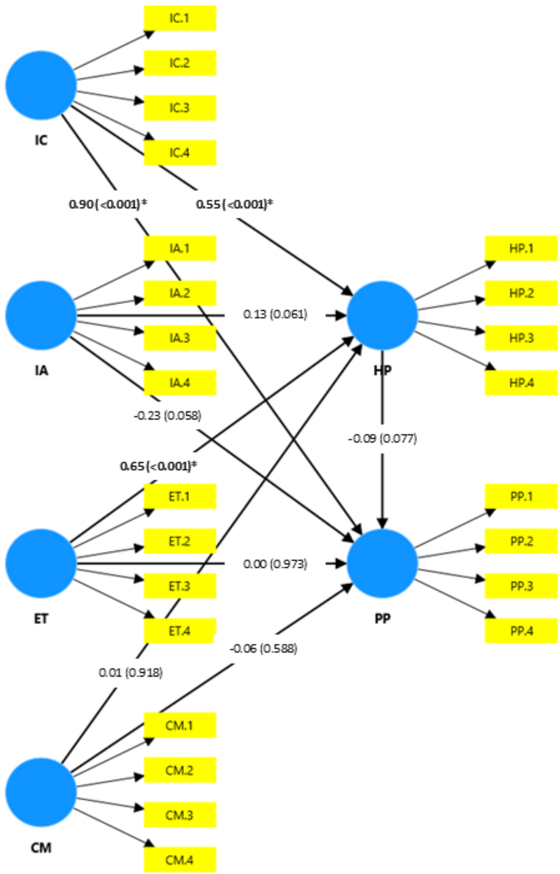

Figure 2. Structural Model

The structural model provides good explanations and predictions, as demonstrated by the R^2 and Q^2 values. The structural model reveals a strong relationship among Context, Criteria, and project performance (β = 0.90). Nevertheless, additional checks were performed to ensure the path coefficients were reasonable and captured the complete picture. When some coefficients were unusually high, the investigation was further examined for multicollinearity, overlapping constructs, and effect sizes. Table 7 presents the findings: the VIF values within the inner matrix clearly indicate collinearity among the predictors for both HSE performance and project performance. Several VIFs exceed the commonly accepted safe limit. This suggests that the ISO 31000 dimensions are not functioning as entirely separate predictors. Rather, they operate together as interconnected elements within the governance process. Therefore, the large coefficients should be interpreted as associations influenced by collinearity, rather than as evidence that any single factor is the main driver in a causal sense.

Beyond statistical significance, effect sizes (f^2) were used to determine which relationships are practically meaningful. Table 8 reveals that execution-oriented risk management practices, particularly Evaluate and Treat and Communication, exert a medium to large influence on HSE performance. In contrast, most direct paths to project performance have minimal effects, except for HSE performance itself, which shows a strong impact.

Table 7. Inner Variance Inflation Factor (VIF) Values

Endogenous Construct	Predictor	Inner VIF
HSE Performance (HP)	Context and Criteria (IC)	6.38
	Identify and Analyse (IA)	11.99
	Evaluate and Treat (ET)	9.82
	Communication (CM)	4.51
Project Performance (PP)	Context and Criteria (IC)	6.40
	Identify and Analyse (IA)	12.24
	Evaluate and Treat (ET)	11.72
	Communication (CM)	5.85
	HSE Performance (HP)	4.44

Note: VIF values above 3.3 indicate potential multicollinearity and warrant cautious interpretation of path coefficients.

Table 8. Effect Size (f^2) of Structural Relationships

Structural Path	f^2 Value	Effect Size Interpretation
IC → HP	0.006	Negligible
IA → HP	0.041	Small
ET → HP	0.287	Medium–Large
CM → HP	0.214	Medium
IC → PP	0.012	Negligible
IA → PP	0.001	Negligible
ET → PP	0.000	Negligible
CM → PP	0.018	Small
HP → PP	0.746	Large

Note: Effect size interpretation follows Hair et al. (0.02 = small, 0.15 = medium, 0.35 = large).

Table 9. Global Model Fit and CMV Diagnostics

Fit / Diagnostic Index	Value	Threshold / Interpretation
SRMR	0.075	Acceptable (< 0.08)
NFI	0.603	Acceptable for PLS-SEM
CMV (procedural remedies)	Applied	Anonymity & voluntary participation
CMV (full collinearity check)	No critical issue	VIFs interpreted cautiously

This pattern highlights that safety outcomes are the principal factor shaping perceptions of project performance in oil and gas construction. Regarding model fit and potential bias, Table 9 addresses these points. The SRMR value falls within the acceptable range for PLS-SEM, indicating a reasonably good fit. The procedural remedies also included performing full-collinearity checks to guard against common method variance, and the results suggest this is not a significant issue. Taken together, these checks support the model's robustness and emphasise the close connections among risk governance, safety performance, and project outcomes.

DISCUSSION AND IMPLICATION

The findings indicate that Context and Criteria (IC) substantially improve HSE performance (β = 0.55, t = 7.09, $p < 0.001$). This finding aligns with Sun et al. [13], who validated that contextualising risks and establishing explicit criteria enhance safety outcomes. For oil and gas projects, it is critical to define the project scope, the hazard context, and the requirements for stakeholders to improve HSE implementation.

IC also has a strong positive effect on project success (β = 0.90, t = 16.60, p < 0.001). This supports findings by Chong and Wang [14], who noted that framing the project context significantly affects its success. In pipeline construction, a clear initial context reduces uncertainty, ensures compliance with rules, and aligns safety with performance goals.

While IA had a positive coefficient, it was not statistically significant (β = 0.13, t = 1.87, p = 0.061). This suggests that simply identifying and analysing risks does not, in itself, improve HSE performance without the implementation of practical measures. Song et al. [20] made similar points, stating that risk identification should be followed by systematic treatment to be effective.

The negative and insignificant effect (β = -0.23, t = 1.90, p = 0.058) indicates that risk identification does not have a direct impact on project performance. Focusing too much on identification without enough mitigation may hinder project progress. This aligns with the views of Ghosh and Jaselskis [19], who asserted that risk identification must be part of decision-making to enhance performance.

Evaluate and Treat (ET) significantly improves HSE performance (β = 0.65, t = 7.34, p < 0.001). This aligns with findings by Guzman et al. [18], who discovered that structured treatment strategies, such as engineering controls and safety drills, decrease accidents on high-risk construction sites.

ET did not significantly affect project performance (β = 0.00, t = 0.03, p = 0.973). This indicates that while ET improves safety outcomes, it does not directly affect costs, schedules, or efficiency. Kallow and Khan [21] reached similar conclusions, noting that treatment strategies primarily focus on safety rather than on project KPIs.

Communication (CM) had no significant effect on HSE performance (β = 0.01, t = 0.10, p = 0.918). This suggests that current communication channels may not be effectively linked to improvements in safety. Edwin et al. [11] contend that communication must be proactive and cross-functional to influence HSE outcomes.

Similarly, CM does not significantly improve project performance (β = -0.06, t = 0.54, p = 0.588). Sarvari et al. [23] stated that structured risk communication should be part of project controls. They noted that poor communication can lead to delays or misalignment.

HSE performance does not significantly affect project performance (β = -0.09, t = 1.77, p = 0.077). This unexpected result suggests that strong safety protocols, while important, may not automatically lead to financial or time benefits. This contrasts with the findings of Sarstedt et al. [25], who reported that safety culture significantly influences project success. This means that in oil and gas projects, external factors such as regulations, market changes, and contract terms may have a greater impact on project performance than improvements in HSE.

To support the survey findings, a Focus Group Discussion (FGD) was conducted with five experts representing project management, HSE, risk analysis, site supervision, and regulatory perspectives. Their input reinforced our results: establishing the right risk context from the outset and implementing treatment measures are essential. However, they also highlighted a shortfall, as risk identification and communication are not yet fully integrated into daily project management practices. These five experts represent different roles:

1. Project Manager (EPC Pipeline Project)
   Emphasised that context-setting (IC) directly shapes both HSE and project outcomes.
   Strategy: Strengthen early risk-framing workshops that involve all stakeholders.
2. HSE Manager (Refinery Construction)
   Highlighted that ET strongly improves HSE but needs budget allocation.
   Strategy: Ensure dedicated funding for risk treatment measures (training, PPE, engineering solutions).
3. Risk Analyst (Oil & Gas Contractor)
   Observed that IA is often done but not integrated with execution.
   Strategy: Link risk registers to project schedules and cost baselines.
4. Site Supervisor (Pipeline Project)
   Reported that communication exists, but often does not reach the workforce effectively.
   Strategy: Implement bottom-up communication channels (toolbox meetings, mobile apps).
5. Government Regulator (Energy Sector)
   Noted that HSE improvements alone may not enhance PP without contractual enforcement.
   Strategy: Include HSE compliance indicators in project performance contracts.

Therefore, several strategies derived from FGD, such as:

1. Strengthen Context and Criteria (IC) through integrated workshops in the planning phase.
2. Allocate dedicated budgets for risk treatment activities (ET) to ensure sustainability.

3. Integrate risk identification (IA) into project control systems so risks translate into actionable mitigation.
4. Enhance risk communication (CM) with digital platforms and workforce-level engagement.
5. Include HSE compliance in project KPIs, enforced contractually to link safety and project performance.

This study builds on existing knowledge by evaluating the application of ISO 31000 in high-risk industrial settings. This contrasts with prior research, which has primarily focused on construction or general infrastructure projects [28]. It supports the view that Context and Criteria (IC) are the most critical aspects of risk management, consistent with the conclusions of Sun et al. [14] and Chong and Wang [15]. The lack of significant mediation of HSE performance challenges earlier findings [25] and raises questions about the role of safety culture in project success [29]. It also considers whether specific industrial contexts, like the oil and gas sector, require different models.

CONCLUSION

This study explores how various components of the ISO 31000 risk management framework influence Health, Safety, and Environment (HSE) performance and overall project outcomes in oil and gas construction. It turns out that Context and Criteria aren't just boxes to check; they're the key drivers. Projects that get this aspect right show real progress in both safety and achieving their objectives. Evaluate and Treat also stands out, providing a notable boost to HSE performance. Interestingly, Identify Analyse and Communication don't have a significant impact on project performance by themselves. Simply running through formal risk procedures isn't enough; what truly counts is how effectively teams adapt and implement these steps.

From a management standpoint, the takeaway is clear. Teams should define risks early, establish clear criteria, and ensure that sufficient resources and authority underpin risk treatment plans. Owners and contractors who incorporate risk context into early planning and governance and support their treatment measures with adequate budgets and firm oversight position themselves for success. For regulators, integrating ISO 31000 principles into contracts and performance assessments appears to be a practical way to enhance safety and keep projects on course, especially when the stakes are high.

Naturally, this study has its limitations. The study is limited to 152 respondents in the Indonesian oil and gas sector, which may limit its applicability to other geographic or industrial contexts. The cross-sectional design does not capture the long-term effects of ISO 31000 implementation throughout the project life cycle. Additionally, the constructs were evaluated through self-reported surveys, which may have been affected by respondent bias.

Therefore, future research should cover additional high-risk areas, such as mining, power generation, and nuclear construction. A long-term study of the impact of ISO 31000 across different stages of the project life cycle could reveal how HSE improvements are reflected more slowly in project outcomes. Future models could incorporate financial, contractual, and digital-transformation factors to improve understanding of the drivers of project performance. Additionally, case studies and ethnographic research might uncover cultural and organisational factors that influence the link between HSE and project success. Lastly, comparative studies between developed and developing countries could provide deeper insights into contextual differences in the implementation of ISO 31000.

Ultimately, this research brings substantial value to the discussion on risk and project management. By demonstrating how ISO 31000 affects both safety and project outcomes, it offers researchers and professionals a validated framework they can put into practice.

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