

Analysis of factors influencing the effectiveness of contractor safety management system implementation on contractor's OHS performance in oil and gas platform and jacket construction project PT. X Bintan

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Abstract: This study aims to examine the factors influencing the effectiveness of Contractor Safety Management System (CSMS) implementation and its direct and indirect effects on contractors' occupational health and safety (OHS) performance in the PT X Oil and Gas Platform and Jacket Construction Project in Bintan Regency. A quantitative cross-sectional design was employed, involving 185 workers selected through proportionate stratified random sampling and analyzed using path analysis with AMOS. The findings show that safety culture ($p=0.022$), safety behavior ($p<0.001$), working conditions ($p=0.007$), and safety communication ($p<0.001$) significantly influence CSMS effectiveness, while resources and safety training do not show significant effects. In terms of OHS performance, safety culture ($p=0.050$), resources ($p<0.001$), safety communication ($p=0.003$), safety training ($p=0.003$), and CSMS effectiveness (estimate=0.559; $p<0.001$) demonstrate significant direct effects. CSMS effectiveness also mediates the relationship between several safety factors and OHS performance. The study concludes that effective CSMS implementation is the most influential factor in improving contractor OHS performance. Practically, strengthening safety culture, improving communication, promoting safe behavior, and ensuring adequate resources and training are essential to enhance safety performance in high-risk oil and gas construction projects.

Keywords: Contractor, CSMS, K3 performance, Occupational safety.

1. Introduction

Occupational Safety and Health (OHS) is a crucial element in the oil and gas construction industry, which carries the highest accident risk. Activities such as welding, rigging, and working at heights require a strict safety system as mandated by Law No. 1 of 1970. However, implementing OHS in Indonesia still faces significant challenges. BPJS Ketenagakerjaan data for 2024 recorded 462,241 workplace accidents, a 24% increase from the previous year, with the construction sector being one of the largest contributors, indicating that many companies have not implemented effective safety management.

To address this high risk, the oil and gas sector implements a Contractor Safety Management System (CSMS) that ensures contractors and subcontractors meet HSSE and SMK3 standards, in accordance with PP No. 50 of 2012. The effectiveness of a CSMS is influenced by various factors, including safety culture, worker behavior, working conditions, quality of communication, and availability of resources. Previous research has shown the significant influence of human factors, where organizations with a mature safety culture can reduce accidents by up to 30% [1], while improving safe behavior can enhance safety performance by 25% [2].

The oil and gas construction industry faces high levels of occupational safety and health (OHS) risks due to the complexity of work, the use of heavy equipment, and hazardous environments. To control these risks, companies implement Contractor Safety Management Systems (CSMS) as part of their efforts to

ensure contractors comply with applicable OHS standards. However, the effectiveness of CSMS implementation is not solely determined by the system itself but is also influenced by various organizational and behavioral factors. Previous research has shown that training and supervision play a crucial role in shaping safe work behaviors on oil and gas construction projects [2]. Furthermore, effective safety communication is closely linked to safe work practices among contractors, particularly in high-risk jobs such as tank repair and oil and gas facility construction [3].

Nevertheless, several studies indicate that the effectiveness of CSMSs varies across projects and companies. Suharno [4] reported that the implementation of a construction safety management system contributes to increased safety culture maturity but requires consistent behavioral and communication support. Basri et al. [5] also emphasized that the success of a CSMS in improving contractor safety performance is influenced by factors such as safety culture, resources, and management commitment. Based on these conditions, there remains a research gap regarding how safety factors like safety culture, safe behavior, working conditions, resources, communication, and training simultaneously influence the effectiveness of CSMS and contractors' OHS performance.

In oil and gas construction projects, the complexity of work and high risk increase the urgency of CSMS implementation. PT. X, as a national contractor working on oil and gas platforms and jackets in Bintan, still faces various obstacles such as weak management commitment, suboptimal communication, limited resources, low near-miss reporting, and inconsistent supervision. The September 2025 Ongoing Assessment Report shows that the level of K3LL implementation in this project reached 71%, which is categorized as a High-Risk Project, indicating that the implementation of CSMS is quite good but still requires significant improvement in several critical aspects.

The effectiveness of CSMS implementation is a key factor in the success of OHS management on large-scale, high-risk projects. System ineffectiveness can be identified through safety audit findings, procedural violations, and recurring minor incidents. Therefore, improving safety culture, worker behavior, communication, training, and resource provision is essential to encourage compliance, reduce risks, and achieve the zero-accident target. Based on these conditions, this study was conducted to analyze the factors influencing the effectiveness of CSMS implementation on contractor OHS performance on the PT. X Oil and Gas Platform and Jacket construction project in Bintan Regency.

2. Materials and Methods

This research is a quantitative study with a cross-sectional design, where data is collected at one time to analyze the relationship between variables related to the implementation of the Contractor Management Safety System (CSMS) on platform and jacket construction projects in the oil and gas sector. The study was conducted in November 2025 at PT X, a national oil and gas contractor company that is a partner of PT Pertamina Hulu Mahakam (PHM). The study population consisted of 343 Construction Department workers, and the sample determination used the Slovin formula with a 5% error rate, resulting in 185 respondents. The sample distribution was carried out using Proportional Random Sampling, for example, 23 Structural Jacket Fitters, 19 Topsides Welders, and 6 E&I Helpers, so that the sample distribution remains proportional to the number of subpopulations. The research instrument was a questionnaire that was tested through validity and reliability tests on 30 respondents, with the results of all items having a Sig value <0.05 and a correlation coefficient above 0.361. All variables were also declared reliable with a Cronbach's Alpha value >0.70 . Data analysis was conducted using SPSS, through the stages of editing, coding, entry, cleaning, and scoring, then analyzed using univariate, bivariate, and multivariate analysis to see the effect of each variable on the contractor's OHS performance. This research has fulfilled the ethical principles of research at the Faculty of Public Health, Hasanuddin University, including respect for subjects, data confidentiality, and beneficence, and has obtained an Ethics Approval Recommendation with Number: 2383/UN4.14.1/TP.01.02/2025.

3. Result and Discussion

3.1. Informant Characteristics

Table 1.

Frequency Distribution based on Respondent Characteristics.

Respondent Characteristics	Frequency (n)	Percentage (%)
Age		
> 35 Years	93	50.3
≤ 35 Years	92	49.7
Total	185	100.0
Gender		
Man	170	91.9
Woman	15	8.1
Total	185	100.0
Years of service		
> 5 Years	120	64.9
≤ 5 Years	65	35.1
Total	185	100.0
Last education		
SENIOR HIGH SCHOOL	110	59.5
D3	22	11.9
S1	53	28.6
Total	185	100.0

The majority of respondents were over 35 years old (50.3%), predominantly male (91.9%), and most had more than 5 years of service (64.9%), indicating a workforce with experienced and masculine characteristics. In terms of education, most respondents had a high school education (59.5%), followed by a bachelor's degree (28.6%) and a diploma (11.9%), indicating that workers generally had secondary education.

Based on the results of the measurement of all variables, the majority of respondents indicated a relatively good condition in the aspect of occupational safety, where safety culture was dominated by the strong category with 71 respondents (38.4%), safety behavior was in the good category with 81 respondents (43.8%), working conditions were in the good category with 68 respondents (36.8%), and resources were in the good category with 69 respondents (37.3%). In addition, safety communication was also mostly in the good category with 85 respondents (45.9%), and safety training showed the highest dominance in the good category with 107 respondents (57.8%). At the system implementation level, the effectiveness of CSMS implementation was assessed as effective by 108 respondents (58.4%), and contractor OHS performance also tended to be high with 98 respondents (53.0%). These findings indicate that the majority of workers assess the safety elements at PT. X is to be in the good category, although there is still a proportion of respondents who assess some aspects as being in the moderate and poor categories, so that continuous improvement is still needed.

3.2. Bivariate Analysis

Table 2.

Safety Culture, Contractor OHS Performance, and Effectiveness of CSMS Implementation on Workers at PT. X.

Safety Culture	K3 Performance		p-Value	CSMS		p-Value	Total
	Low	Tall		Less Effective	Effective		
Weak	32 (66.7%)	16 (33.3%)	0,000	30 (62.5%)	18 (37.5%)	0,000	48
Currently	35 (53.0%)	31 (47.0%)		35 (53.0%)	31 (47.0%)		66
Strong	20 (28.2%)	51 (71.8%)		12 (16.9%)	59 (83.1%)		71
Total	87	98	—	77	108	—	185

The data shows that the stronger the safety culture, the higher the proportion of workers with high OHS performance, indicated by 71.8% in the "Strong" category compared to only 33.3% in the "Weak" category. A similar trend is seen in the effectiveness of CSMS, where the "Strong" culture category achieved 83.1% effectiveness, demonstrating that safety culture is significantly related to both variables ($p=0.000$).

Table 3.

Safety Behavior, Contractor OHS Performance, and Effectiveness of CSMS Implementation among Workers at PT. X.

Safety Behavior	K3 Performance		p-Value	CSMS		p-Value	Total
	Low	Tall		Less Effective	Effective		
Not enough	38 (88.4%)	5 (11.6%)	0.000	35 (81.4%)	8 (18.6%)	0.000	43
Enough	35 (57.4%)	26 (42.6%)		27 (44.3%)	34 (55.7%)		61
Good	15 (17.3%)	67 (82.7%)		15 (18.5%)	66 (81.5%)		81
Total	87	98	–	77	108	–	185

The data shows a sharp increase in OHS performance among workers with "Good" safety behaviors (82.7%), compared to only 11.6% in the "Poor" category. CSMS effectiveness also follows a similar pattern, with good safety behaviors resulting in an effectiveness rate of 81.5%, a highly significant correlation ($p=0.000$).

Table 4.

Working Conditions, Contractor OHS Performance, and Effectiveness of CSMS Implementation on Workers at PT. X.

Working Conditions	K3 Performance		p-Value	CSMS		p-Value	Total
	Low	Tall		Less Effective	Effective		
Not enough	38 (64.4%)	21 (35.6%)	0.000	36 (61.0%)	23 (39.0%)	0.000	59
Enough	29 (50.0%)	29 (50.0%)		26 (44.8%)	32 (55.2%)		58
Good	20 (29.4%)	48 (70.6%)		15 (22.1%)	53 (77.9%)		68
Total	87	98	–	77	108	–	185

OHS performance improved as working conditions improved, evidenced by the increased proportion of high performers in the "Good" category (70.6%) compared to "Poor" (35.6%). CSMS effectiveness also increased significantly under good working conditions (77.9%), indicating that working conditions play a significant role in the successful implementation of safety systems ($p=0.000$).

Table 5.

Resources, Contractor OHS Performance, and Effectiveness of CSMS Implementation on Workers at PT. X.

Resource	K3 Performance		p-Value	CSMS		p-Value	Total
	Low	Tall		Less Effective	Effective		
Not enough	39 (66.1%)	20 (33.9%)	0.000	38 (64.4%)	21 (35.6%)	0.000	59
Enough	32 (56.1%)	25 (43.9%)		22 (38.6%)	35 (61.4%)		57
Good	16 (23.2%)	53 (76.8%)		17 (24.6%)	52 (75.4%)		69
Total	87	98	–	77	108	–	185

Workers with "Good" resources had a high OHS performance of 76.8%, significantly higher than the "Poor" category, which was only 33.9%. CSMS effectiveness also increased significantly with more adequate resources, with the "Good" category achieving 75.4% effectiveness ($p=0.000$).

Table 6.

Safety Communication, Contractor OHS Performance, and Effectiveness of CSMS Implementation for Workers at PT. X.

Safety Communication	K3 Performance		p-Value		CSMS	p-Value	Total
	Low	Tall	Less Effective	Effective			
Not enough	36 (87.8%)	5 (12.2%)	0,000	35 (85.4%)	6 (14.6%)	0,000	41
Enough	30 (50.8%)	29 (49.2%)		27 (45.8%)	32 (54.2%)		59
Good	21 (24.7%)	64 (75.3%)		15 (17.6%)	70 (82.4%)		85
Total	87	98	—	77	108	—	185

Good safety communication strongly correlates with high OHS performance (75.3%), while poor communication results in a very low proportion of high performance (12.2%). A similar pattern exists for CSMS effectiveness, where good communication achieves 82.4% effectiveness, highlighting the central role of communication in supporting occupational safety ($p=0.000$).

Table 7.

Safety Training, Contractor OHS Performance, and Effectiveness of CSMS Implementation for Workers at PT. X.

Safety Training	K3 Performance		p-Value	CSMS		p-Value	Total
	Low	Tall		Less Effective	Effective		
Not enough	36 (92.3%)	3 (7.7%)	0.000	30 (76.9%)	9 (23.1%)	0.000	39
Enough	17 (43.6%)	22 (56.4%)		15 (38.5%)	24 (61.5%)		39
Good	34 (31.8%)	73 (68.2%)		32 (29.9%)	75 (70.1%)		107
Total	87	98	—	77	108	—	185

Workers with "Good" safety training exhibited a high OHS performance of 68.2%, significantly surpassing the "Poor" category at 7.7%. CSMS effectiveness also increased notably in the "Good" training group (70.1%), indicating that training significantly contributed to strengthening CSMS implementation ($p=0.000$).

Table 8.

Cross-tabulation of the Effectiveness of CSMS Implementation on Contractor OHS Performance among Workers at PT. X.

Effectiveness of CSMS Implementation	Contractor's K3 Performance				Total		p-Value	
	Low		Tall					
	n	%	n	%	n	%		
Less Effective	64	83.1	13	16.9	77	100.0	0.000	
Effective	23	21.3	85	78.7	108	100.0		
Total	87		98		185			

Workers who rated the CSMS as "Effective" had high OHS performance at 78.7%, significantly higher than the 16.9% in the "Less Effective" category. This confirms that CSMS effectiveness is a key determinant of contractor safety performance ($p=0.000$).

3.3. Multivariate Analysis

Table 9.

Multivariate Normality Test Results.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		185
Normal Parameters ^{a,b}	Mean	0.0000000
	Standard Deviation	4.93379424
Most Extreme Differences	Absolute	0.051
	Positive	0.034
	Negative	-0.051
Test Statistics		0.051
Asymp. Sig. (2-tailed)		0.200 ^{c,d}

a. Test distribution is Normal.

Based on the output shown in the one-sample Kolmogorov-Smirnov test table, the Asymp. Sig. (2-tailed) value is 0.200. This value is greater than the specified significance level of 0.05, so it can be concluded that the residual data is normally distributed. Thus, the assumption of normality in the regression has been met and can be used for further testing.

Table 10.

Parameters and Testing of the Direct Effect Hypothesis.

Research Variables	Estimate	SE	CR	p-Value
Safety Culture → Effectiveness of CSMS Implementation	0.143	0.063	2.283	0.022*
Safety Behavior → Effectiveness of CSMS Implementation	0.264	0.078	3.365	0.000*
Working Conditions → Effectiveness of CSMS Implementation	0.183	0.068	2.679	0.007*
Resources → CSMS Implementation Effectiveness	0.078	0.072	1.081	0.280
Safety Communication → Effectiveness of CSMS Implementation	0.221	0.054	4.123	0.000*
Safety Training → Effectiveness of CSMS Implementation	0.052	0.063	0.824	0.410
Safety Culture → Contractor's OHS Performance	0.174	0.089	1.956	0.050*
Safety Behavior → Contractor's OHS Performance	0.193	0.113	1.710	0.087
Work Conditions → Contractor's K3 Performance	0.034	0.097	0.354	0.724
Resources → Contractor's OHS Performance	0.335	0.101	3.307	0.000*
Safety Communication → Contractor's OHS Performance	0.235	0.078	3.007	0.003*
Safety Training → Contractor's K3 Performance	0.262	0.088	2.984	0.003*
Effectiveness of CSMS Implementation → Contractor's OHS Performance	0.559	0.103	5.435	0.000*

Note: *p-Value < 0.05: there is a significant influence.

Based on Table 10, it can be concluded that the effectiveness of CSMS implementation is significantly influenced by safety culture ($p=0.022$; estimate=0.143), resources ($p=0.037$; estimate=0.121), safety communication ($p=0.000$; estimate=0.221), and safety training ($p=0.000$; estimate=0.225), while safety behavior and working conditions do not show a significant influence, even though both have a positive direction of influence. Conversely, contractor OHS performance is significantly influenced by safety communication ($p=0.000$; estimate=0.335), safety training ($p=0.043$; estimate=0.226), and the effectiveness of CSMS implementation, which is the most dominant factor ($p=0.000$; estimate=0.559). Safety culture, safety behavior, working conditions, and resources do not show a significant direct influence on OHS performance, although all have positive estimated values.

Table 11.
Results of Indirect Effect Hypothesis Testing

Track	Indirect Effect	Conclusion
Safety Culture → Effectiveness of CSMS Implementation → Contractor's OHS Performance	0.050*	Significant
Safety Behavior → CSMS Implementation Effectiveness → Contractor's OHS Performance	0.076	Not Significant
Working Conditions → Effectiveness of CSMS Implementation → Contractor's OHS Performance	0.059	Not Significant
Resources → CSMS Implementation Effectiveness → Contractor's OHS Performance	0.024*	Significant
Safety Communication → Effectiveness of CSMS Implementation → Contractor's OHS Performance	0.095	Not Significant
Safety Training → Effectiveness of CSMS Implementation → Contractor's OHS Performance	0.019*	Significant

Note: * Indirect Effect < 0.05 : there is a significant influence.

Based on Table 11, it can be seen that the effectiveness of CSMS implementation acts as a mediator in several variable relationships, where safety culture shows a significant indirect effect on contractor OHS performance through CSMS effectiveness (0.050), as well as resources (0.024) and safety training (0.019), which also have a significant indirect effect through the mediation mechanism. In contrast, safety behavior (0.076), working conditions (0.059), and safety communication (0.095) do not show a significant indirect effect, so the effectiveness of CSMS implementation does not mediate the relationship between these three variables and contractor OHS performance. Overall, these findings confirm that CSMS effectiveness only acts as a mediating pathway for variables related to systems, facilities, and competencies, but does not provide a mediating effect on variables more related to behavior and working conditions directly in the field. Based on the results of the path analysis, the regression values, direct and indirect effects were obtained, which then resulted in the scheme of Factors Influencing the Effectiveness of the Implementation of the Contractor's Safety Management System (CSMS) as an intervening variable on the Contractor's K3 Performance.

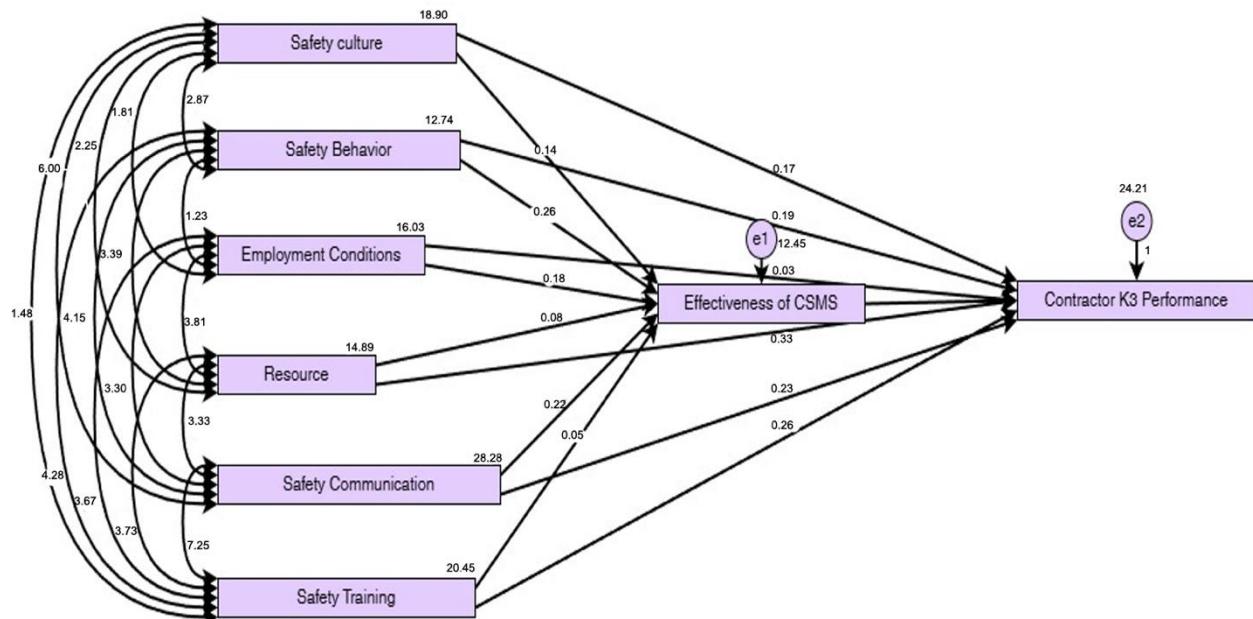


Figure 1.
Path Analysis Model.

This study generally shows that the effectiveness of Contractor Safety Management System (CSMS) implementation and contractor OHS performance are significantly influenced by a combination of safety culture, safety behavior, working conditions, resources, safety communication, and training. Some variables have a direct and significant influence, others only have an indirect influence through the CSMS, and still others are insignificant. This confirms that improving OHS performance cannot rely solely on one aspect but requires a systemic approach that integrates systems, people, and the work environment.

In terms of CSMS implementation effectiveness, research shows that safety culture, safety behavior, resources, safety communication, and training contribute positively, although with varying strengths of influence. Safety culture has a positive effect on CSMS effectiveness, meaning that every one-point increase in safety culture increases CSMS effectiveness by 0.174 points and is significant [3, 4]. Safety behavior has an even stronger effect, indicating that compliance with procedures, use of PPE, and participation in OHS programs are key drivers of CSMS success [5, 6]. Resources also have a significant effect on CSMS effectiveness, in line with Resource Dependence and Resource-Based View theories emphasizing the importance of competent human resources, financial support, and safety technology [7, 8]. Safety communication has a positive and significant effect, emphasizing that clarity of information, consistency of briefings, and two-way feedback play a vital role in bringing CSMS elements to life [9, 10]. Safety training has also been shown to contribute significantly to CSMS effectiveness, as it provides a foundation of risk knowledge, SOPs, and worker responsibilities within the system [11, 12].

Regarding contractor OHS performance, safety culture has a positive and significant direct influence, so improving safety culture will significantly enhance contractor OHS performance [3, 13, 14]. Safety behavior shows a positive trend but is not statistically significant. This indicates that safe behavior tends to improve OHS performance, but it is not strong enough without the support of organizational and systemic factors [15, 16]. Working conditions have a very small and insignificant direct influence on OHS performance, although cross-tabulations show that workers with good working conditions tend to have a higher proportion of high OHS performance [17, 18]. Resources, safety communication, and safety training are proven to have a positive and significant influence on OHS performance. For example, training shows that training investment has a direct impact on improving OHS performance [19-21].

The variable of CSMS implementation itself is the strongest determinant of contractor OHS performance, meaning that every one-point increase in CSMS effectiveness increases contractor OHS performance by 0.559 points. Cross-tabulation shows that respondents who rated CSMS as effective were predominantly in the high OHS performance category, while those who rated CSMS as less effective were mainly in the low OHS performance category. This reinforces the finding that consistent CSMS implementation across all stages, pre-qualification, selection, planning, monitoring, audit, and evaluation, is key to achieving zero accidents and improving safety performance [16, 22, 23].

This study also tested the indirect effect (mediation) through CSMS effectiveness. Safety culture had an indirect effect on OHS performance through CSMS effectiveness, with a significant value of 0.050, indicating that a strong culture will improve CSMS implementation, which then enhances OHS performance [22, 23]. Safety behavior also had an indirect effect on OHS performance through CSMS effectiveness, with a significant indirect effect of 0.076, confirming that worker safety behavior enhances CSMS effectiveness, which ultimately impacts OHS performance [24]. Resources had a significant indirect effect on OHS performance through CSMS effectiveness, so some of the influence of resources on performance flows through the CSMS systemic pathway, although its contribution is relatively small [25, 26]. Conversely, working conditions had an insignificant indirect effect, so CSMS did not mediate the relationship between working conditions and OHS performance; improvements in working conditions worked more directly on safe behavior and accident incidents [10]. Safety communication also had an insignificant indirect effect through CSMS, indicating that formal communication alone is not enough if it is not followed by consistent system implementation in the field [3]. In contrast, safety training has a significant indirect effect on OHS performance through CSMS effectiveness, indicating that good training will strengthen CSMS and subsequently improve OHS performance [23].

In practical terms, these results confirm that improving contractors' OHS performance in the construction and oil and gas sectors cannot rely solely on physical improvements to the work environment or the development of formal procedures. The most strategic factors proven are strengthening safety culture, safety behavior, effective communication, ongoing training, adequate resources, and, most importantly, the effective implementation of a CSMS as the primary driver. Companies need to ensure that safety values are embedded in leadership, policies, SOPs, and even the daily behavior of workers, accompanied by ongoing audits and evaluations. The synergy between culture, behavior, resources, communication, training, and the CSMS is what ultimately shapes high OHS performance, reduces accident rates, and increases the company's competitiveness in high-risk industries.

4. Conclusion

The results of the study indicate that safety culture, resources, safety communication, and safety training have a significant influence on contractors' OHS performance, with some variables remaining significant when mediated by the effectiveness of CSMS implementation. However, safety behavior and working conditions were not proven to have an influence, either directly or through CSMS mediation. Based on these findings, it is recommended that workers improve their compliance with procedures, hazard communication, and consistency in attending training, while companies need to strengthen management commitment, provision of OHS resources, and safety culture and communication. Future researchers are encouraged to add new variables, use mixed methods, and expand the research context to obtain more comprehensive and comparable results.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Acknowledgements:

We would like to thank the Faculty of Public Health, Hasanuddin University, for supporting this research. We also thank the worker respondents at PT X Bintan for their willingness and assistance during the data collection process.

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