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Evaluating Safety Culture Maturity in Indonesian Petrochemical Industry to Strengthen Occupational Health Systems

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ABSTRACT

Introduction: This study aimed to assess the maturity of safety culture implementation across petrochemical companies in Indonesia. By using a mixed-methods to provide a comprehensive understanding of occupational health and safety risks in high-hazard industries. The petrochemical sector being prone to workplace accidents and process related to incidents. The objective was to identify the maturity level of safety practices and highlight priority areas for improvement, addressing gaps in existing literature on safety culture measurement in industrial settings.

Methods: This cross-sectional mixed-methods study involved surveys and observations conducted across 10 petrochemical companies in 2024. A total of 513 participants were enrolled, and data were collected through validated questionnaires, plant visits, and document reviews. Ethical approval was obtained from the Faculty of Public Health Universitas Indonesia and participants provided informed consent.

Results: The primary outcome of the study was the maturity level of safety culture, which most respondents rated as "Generative." Based on company type significant differences ($p < 0.05$) were found in commitment. While other variables such as information, organizational learning, employee participation, and communication showed no significant differences. There were no significant differences based on industry type and role type for each variable. The findings from qualitative method indicate that most companies have implemented both national safety standards namely SMK3 (Occupational Health and Safety Management System) and international systems (including ISO 45001, OSHA PSM, ILO PSM, and Responsible Care).

Conclusion: In conclusion, the importance of a mature safety culture in supporting occupational health and safety practices and highlights the need for continuous improvement in workplace safety systems. Future studies should explore interventions that strengthen these dimensions, helping reduce occupational risks in the petrochemical industry.

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INTRODUCTION

Occupational safety is a major public health concern, especially in highrisk industries such as petrochemicals. Data from global industrial accident reports show that process safety failures have caused severe injuries, fatalities, and environmental damage, leading to economic losses in the millions or even billions of dollars (1). In Indonesia, the petrochemical industry faces similar risks due to its complex operations and the use of hazardous materials under extreme pressure and temperature. Occupational incidents continue to occur in the petrochemical industry, despite the presence of formal safety regulation. Many companies have adopted safety management systems in accordance with national regulations from Minister of Manpower Regulation No. 5/2018 and Minister of Industry Regulation No. 19/2019. However, the persistence of workplace accidents suggests that regulatory compliance alone may not be sufficient to ensure workplace safety.

Indonesia's petrochemical industry, with many plants operating for over 25 years, faces unique challenges in maintaining robust health and safety standards amid economic growth and technological change. Although regulations and international standards have been adopted, incidents related to occupational health persist, highlighting the need for strengthening systemic preventive measures through cultural change. The term "safety culture" was first introduced in the International Nuclear Safety Advisory Group (INSAG) report on the 1986 Chernobyl disaster. Researchers highlighted those operational errors and procedural violations contributing to the disaster reflected a poor safety culture, demonstrating that although safety culture may seem intangible, it has very real and serious consequences (2). Unlike traditional compliance-based safety assessments that focus primarily on whether procedures and policies are in place, safety culture maturity models evaluate the depth of safety values, behaviors, and leadership commitment embedded within the organization (3). These models offer a more dynamic and developmental perspective, helping organizations to identify not just what is done, but how and why safety practices are embraced at all levels (4).

Previous studies have shown that a strong safety culture plays a crucial role in improving the effectiveness of health safety management systems and preventing workplace accidents (5). However, most existing studies in Indonesia's petrochemical sector have focused on regulatory compliance and occupational safety in general rather than the maturity of safety culture. The concept of safety culture maturity helps organizations understand where they stand in applying safety values and identify areas that need improvement (6). While some studies have applied maturity models in industries such as aviation or nuclear energy, limited research has applied this approach in Indonesia's petrochemical sector. Since the concept of safety culture can differ across organizations, the approaches used to assess safety culture maturity also vary accordingly (7).

The concepts of safety culture and safety psychology are recognized as essential in preventing large scale and systemic accidents, as well as in supporting the longterm development of organizations. To better understand how safety culture evolves, several models have been proposed, including Hudson's Safety Culture Ladder, which conceptualizes cultural development along a continuum from pathological to generative stages (8–10). These maturity models help visualize how organizations can progressively develop and integrate safety into their operational mindset over time (8). Research has shown that organizations with well-established health and safety management systems, but weak safety cultures, often face challenges in ensuring consistent safety-related decision-making. Conversely, organizations with a strong safety culture but lacking formal safety systems may demonstrate inconsistent performance, with limited resources and weak alignment between safety and business objectives (9).

The concepts of safety culture and safety psychology are seen as essential for preventing large scale and systemic accidents, and for ensuring the longterm development of companies. The cultural maturity model has been proposed to visualize how organizations should address and develop safety over time (11). Research has shown that organizations with established health safety management systems, but weak safety cultures often struggle to ensure consistent safety related decision making. Conversely, organizations with a strong safety culture but without a formal health safety management system may operate inconsistently, with insufficient resources and weak integration of safety into business drivers (12).

This study addresses that gap by assessing the maturity level of safety culture in Indonesian petrochemical companies. Understanding the current level of safety culture maturity can support targeted improvements and interventions to enhance occupational health outcomes. This research also aims to identify specific safety culture

dimensions such as information, communication, learning, commitment, and employee participation, that require attention to strengthen health safety practices.

Therefore, the objectives of this study are to evaluate the implementation of health safety values across petrochemical installations using a safety culture maturity model and to identify priority areas for improving occupational health systems in Indonesia's petrochemical industry.

METHOD

Research Type

This study employed a mixed-methods cross-sectional design to assess the maturity level of safety culture implementation in the Indonesian petrochemical industry. Quantitative data were gathered through an online structured questionnaire distributed to employees and safety managers in the petrochemical industry. A total of 513 participants were analyzed using descriptive and correlation analyses. Qualitative findings were checklist-analyzed to enrich and contextualize the survey results; data were collected through observational and document reviews.

Population and Sample/Informants

The study population consisted of workers and health safety managers from 10 petrochemical companies across Java Island, Indonesia. These companies include both multinational and local firms involved in the production of plastic raw materials and non-plastic raw materials. Stratified proportional random sampling was used to ensure balanced representation across company types and roles. A total of 513 participants were surveyed from July to December 2024, with inclusion focused on those involved in production and health safety related tasks.

Research Location

The research was conducted in petrochemical industrial areas located across Java Island, Indonesia, where multiple chemical processing facilities operate under varying health safety standards and organizational systems.

Instrumentation or Tools

The primary tool was a structured questionnaire designed to measure safety culture maturity across five dimensions: information, organizational learning, employee participation, communication, and commitment. A structured questionnaire was used to assess organizational safety maturity. This questionnaire model has been tested and validated in three different types of industrial organizations in Brazil for chemical manufacturing, petrochemical, and footwear industries. The instrument comprised three main parts: (1) general company information and safety implementation completed by the safety officer, (2) organizational safety culture maturity perception, and (3) Safety Culture Maturity Questionnaire (SCMQ) assessing five maturity levels. Each dimension consisted of 22 statements, and each statement included five graded response items corresponding to the five maturity levels:

Level 1: Pathological ("We don't care as long as no one gets hurt.")
Level 2: Reactive ("We act only after incidents happen.")
Level 3: Bureaucratic ("We have systems, but not always implemented.")
Level 4: Proactive ("We actively try to prevent incidents.")
Level 5: Generative ("Safety is how we do business.")

This structure resulted in a total of 110 items (22 statements × 5 graded items). The instrument's reliability was confirmed with a Cronbach's alpha score of 0.91, indicating excellent internal consistency. Construct validity was assessed using corrected item-total correlation, with all items exceeding the acceptable threshold of 0.30, supporting the instrument's validity. In addition to the questionnaire, qualitative data were obtained through an observation checklist and document review, used to triangulate the quantitative findings and provide deeper insight into organizational practices and safety culture maturity.

Data Collection Procedures

Quantitative and qualitative data were collected concurrently between July and December 2024. The quantitative phase, data were collected using a structured questionnaire via Google Forms. The survey link was distributed through WhatsApp to health and safety managers at participating companies, who then disseminated it

internally to relevant respondents. Participation was voluntary, anonymous, and conducted with digital informed consent. While the use of WhatsApp allowed for efficient and wide-reaching distribution, it may introduce sampling bias or response limitations. The overrepresentation of digitally literate participants or limited control over who ultimately completed the questionnaire. This limitation is acknowledged as a potential source of bias that may affect the generalizability of findings.

To support triangulation and enhance the robustness of the findings, qualitative data were also gathered through on-site observational visits and document reviews at selected companies. These qualitative components helped contextualize the quantitative responses and provide insight into workplace practices and safety culture maturity. Ethical clearance was obtained from a recognized institutional ethics board, and informed consent was obtained digitally.

Data Analysis

Quantitative data were analyzed using SPSS version 22. Descriptive statistics were used to determine safety culture maturity levels, and chi-square tests identified differences across company types and maturity dimensions. Qualitative data from observations and document reviews and analyzed thematically to explore regulation and system implementation.

Ethical Approval

This study was approved by the Research and Community Engagement Ethical Committee of Faculty of Public Health Universitas Indonesia (Approval Number: 65/UN2.F10.D11/PPM.00.02/2024). All participants provided informed consent prior to participating in the study. The confidentiality of all participants was strictly maintained throughout the research process.

RESULTS

The results showed that in terms of industry type, 51.1% of respondents were from the Plastic Raw Materials industry, while 48.9% were from Non-Plastic Raw Materials industry. Regarding company type, 46.8% of respondents came from Multinational Companies (MNCs), and 53.2% were from Non-Multinational Companies (Non-MNCs). The majority of respondents were male (92.2%), with only 7.8% female respondents. Table 1 shows that most respondents were aged 31–40 years (32.7%), while the smallest group was aged 21–30 years (18.1%). In terms of education, the largest group held a high school diploma (51.1%), followed by those with a bachelor's degree (40.5%). Regarding years of service, the largest proportion of respondents had 26–30 years of experience (22.2%), while the smallest groups had less than 1 year (2.5%) and more than 31 years (4.5%).

These demographic characteristics are relevant in interpreting the maturity of safety culture. For instance, the high proportion of respondents with long service (over 20 years). This may suggest a more experienced workforce, potentially contributing to higher maturity scores in areas such as commitment and organizational learning. Similarly, the significant representation from MNCs, which often have structured safety systems, could influence higher maturity levels across multiple dimensions. Particularly in communication and information dissemination. Conversely, the predominance of respondents with high school education may indicate areas for further capacity building, especially in understanding and participating in advanced safety practices.

Table 1. Demographic Data Analysis of Respondents

No	Demographic	Category	n (%)
1	Industry Type	Plastic Raw	262 (51.1)
		Non-Plastic Raw	251 (48.9)
2	Company Type	MNC	240 (46.8)
		Non-MNC	273 (53.2)
3	Gender	Male	473 (92.2)
		Female	40 (7.8)
4	Age*	21-30	93 (18.1)
		31-40	168 (32.7)

		41-50	119 (23.3)
		51-60	133 (25.9)
5	Education	High School	262 (51.1)
		Associate degree	34 (6.6)
		Bachelor's	208 (40.5)
		Master's	9 (1.8)
6	Work Experience*	<1	13 (2.5)
		1-5	106 (20.7)
		6-10	57 (11.1)
		11-15	82 (16.0)
		16-20	70 (13.6)
		21-25	48 (9.4)
		26-30	114 (22.2)
		>31	23 (4.5)

Source: Primary Data (*years)

Table 2 presents the frequency distribution of safety culture maturity dimensions based on industry type, comparing organizations in the plastic raw material and non-plastic raw material sectors. The findings reveal that the majority of respondents from both industry types rated all five dimensions of information, organizational learning, employee participation, communication, and commitment at the highest level of maturity, categorized as "Generative" with percentages ranging from 78.5% to 93.2%. Although all p-values exceeded 0.05, indicating no statistically significant differences between the two groups, further examination of the data (Figure 1) reveals subtle yet meaningful trends. For example, the Plastic Raw Materials industry shows slightly higher scores in Information (90.1%) and Employee Participation (79.8%), suggesting a stronger emphasis on transparent communication and involvement at the operational level. In contrast, the Non-Plastic Raw Materials industry shows marginally higher ratings in Organizational Learning (92.0%), Communication (89.2%), and Commitment (93.2%), which may reflect a stronger alignment of management attitudes and systems with proactive safety practices.

The information and employee involvement variables are marginally higher in plastic raw material industries, while organizational learning, communication, and commitment are slightly higher in non-plastic raw industries. These findings indicate that overall, both industry types demonstrate a similar level of safety culture maturity, with no substantial gaps across the five measured variables. The implementation of safety practices was consistently strong in both sectors, regardless of production type. These nuances suggest that while overall maturity is high and consistent across sectors, industry specific emphases exist. Plastic raw material companies may prioritize practical information dissemination and workforce engagement, while non-plastic raw companies may be more focused on organizational adaptability and leadership commitment. Importantly, these differences do not reflect systemic gaps, but rather differentiated strengths in implementation focus, both converging toward a generative safety culture.

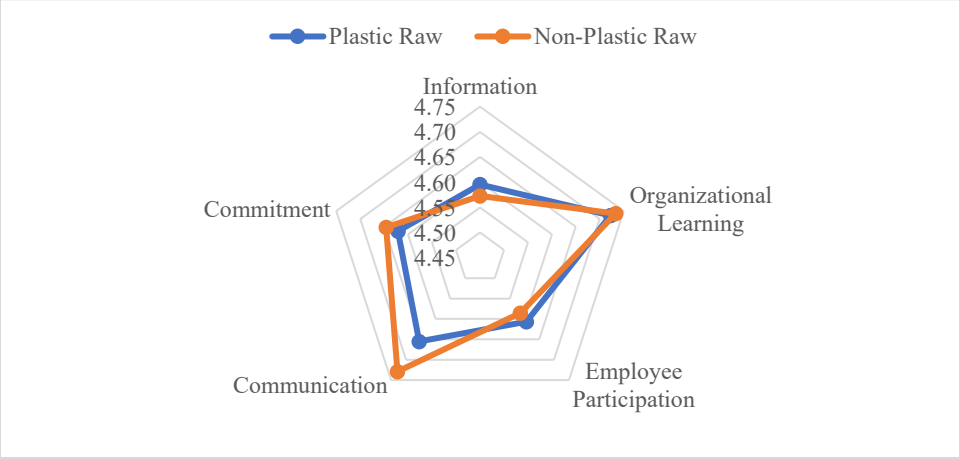

Figure 1. Descriptive Analysis of Safety Culture Maturity Based on Industry Type

Table 2. Distribution of Safety Culture Maturity Dimensions by Industry Type

No	Variable	Category	Pathological (%)	Reactive (%)	Calculative (%)	Proactive (%)	Generative (%)	p-value
1	Information	Plastic	0,0	0,8	1,1	8,0	90,1	0,450
		Non	0,0	2,0	2,4	7,6	88,0	
2	Organizational Learning	Plastic	0,0	0,4	1,9	5,0	92,7	0,790
		Non	0,0	0,8	1,2	6,0	92,0	
3	Employee Participation	Plastic	0,0	0,4	1,1	18,7	79,8	0,612
		Non	0,0	0,4	2,8	18,3	78,5	
4	Communication	Plastic	0,4	0,8	0,8	11,8	86,3	0,491
		Non	0,0	0,0	0,8	10,0	89,2	
5	Commitment	Plastic	0,0	1,1	1,1	6,5	91,2	0,375
		Non	0,0	0,0	1,2	5,6	93,2	

Source: Primary Data

Table 3 compares the distribution of safety culture maturity levels between multinational companies (MNC) and non-multinational companies (non-MNC) across five key dimensions: Information, Organizational Learning, Employee Participation, Communication, and Commitment. The majority of respondents from both groups rated all dimensions at the "Generative" level. With maturity percentages ranging from 76.6% to 95.4%, indicating overall high safety culture performance. Statistical analysis revealed no significant differences ($p > 0.05$) across four dimensions. However, a statistically significant difference was found in the Commitment dimension ($p = 0.047$), suggesting that MNCs exhibit a notably stronger leadership commitment to safety than their non-MNC counterparts.

As illustrated in Figure 2, MNCs consistently scored higher across all five dimensions. The most prominent gap appears in Commitment and Communication, where MNCs reached scores above 95% and 91% Generative, respectively, while non-MNCs scored 89.4% and 84.6%. Interestingly, while Employee Participation showed a smaller gap (MNC = 82.1%, non-MNC = 76.6%), this suggests that non-MNCs may involve employees relatively well but perhaps lack the systematic backing seen in MNCs. Moreover, Organizational Learning and Information Sharing were also slightly higher in MNCs, further supporting the notion of more institutionalized learning processes. These insights suggest that while both MNC and non-MNC companies demonstrate a generally mature safety culture, MNCs appear to lead with greater consistency and leadership involvement, which may contribute to a more sustainable culture of safety.

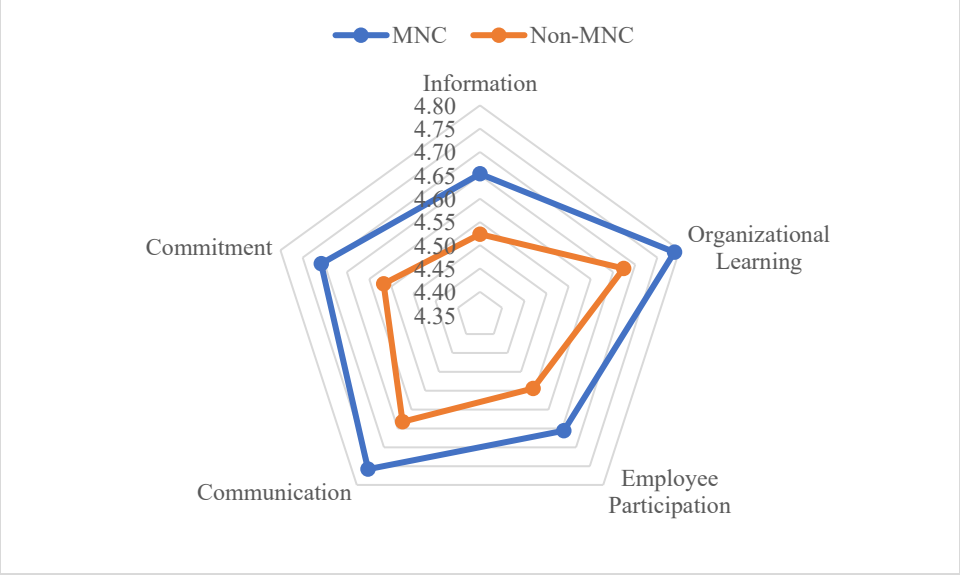

Figure 2. Descriptive Analysis of Safety Culture Maturity Based on Company Type

Table 3. Frequency Distribution of Safety Culture Maturity Dimensions Based on Company Type

No	Variable	Category	Pathological (%)	Reactive (%)	Calculative (%)	Proactive (%)	Generative (%)	p-value
1	Information	MNC	0,0	0,8	1,3	5,8	92,1	0,233
		Non-MNC	0,0	1,8	2,2	9,5	86,4	
2	Organizational Learning	MNC	0,0	0,0	0,4	5,0	94,6	0,078
		Non-MNC	0,0	1,1	2,6	5,9	90,5	
3	Employee Participation	MNC	0,0	0,0	0,8	17,1	82,1	0,131
		Non-MNC	0,0	0,7	2,9	19,8	76,6	
4	Communication	MNC	0,0	0,0	0,4	8,3	91,3	0.147
		Non-MNC	0,4	0,7	1,1	13,2	84,6	
5	Commitment	MNC	0,0	0,0	0,4	4,2	95,4	0,047*
		Non-MNC	0,0	1,1	1,8	7,7	89,4	

Source: Primary Data (*p<0.05)

Table 4 presents the frequency distribution of safety culture maturity levels based on respondent roles, comparing staff members and managers across five key dimensions: Information, Organizational Learning, Employee Participation, Communication, and Commitment. The findings show that both groups predominantly rated their organizations at the "Generative" maturity level. Notably, all managerial respondents rated 100% Generative across all five dimensions that suggesting a highly favorable view of safety culture implementation from leadership perspectives. Despite this uniform rating among managers, Chi-square test results showed no statistically significant differences between staff and manager responses for any of the five dimensions (p-values ranging from 0.741 to 0.852). This suggests statistical homogeneity in responses, although visual analysis offers deeper insight.

As illustrated in Figure 3, managers consistently rated each dimension higher than staff. The most substantial perception gaps were observed in Communication and Employee Participation, where managers gave perfect scores (100% Generative), while staff responses were slightly lower (87.5% and 78.9%, respectively). These gaps may indicate that managers perceive the presence of safety systems and engagement strategies more optimistically, perhaps due to their role in designing or overseeing such systems. On the other hand, staff responses reflect their direct experience with implementation on the ground, possibly revealing challenges in each day safety communication or engagement. This perceptual disparity points to a potential blind spot in how safety leadership evaluates the effectiveness of their strategies compared to the realities experienced by frontline employees. Overall, while the maturity levels are high across both groups, this analysis suggests that organizations may benefit from bridging perception gaps through more bottom-up feedback mechanisms and ensuring that managerial assessments were informed by staff level realities.

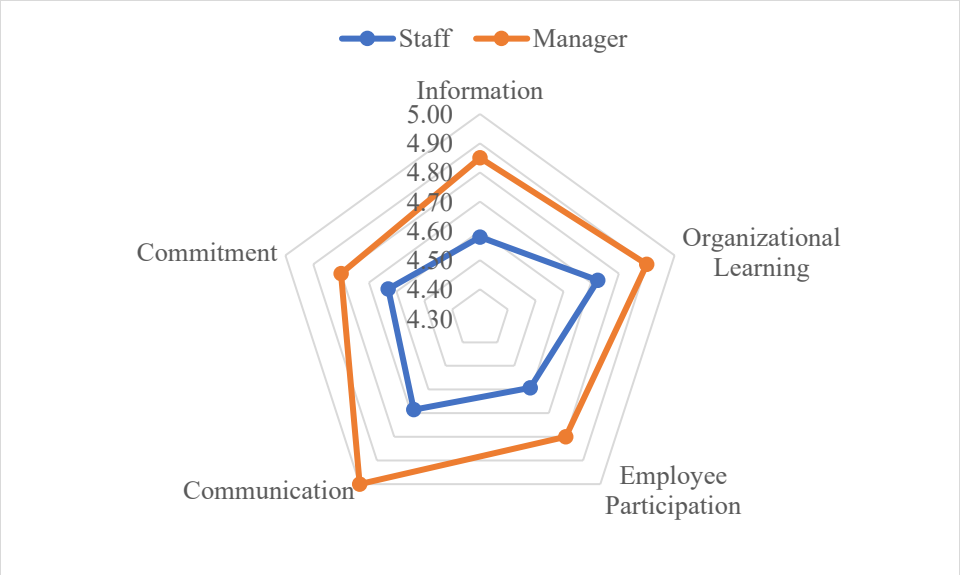

Figure 3. Descriptive Analysis of Safety Culture Maturity Based on Role Type

Table 4. Frequency Distribution of Safety Culture Maturity Dimensions Based on Role Type

No	Variable	Category	Pathological (%)	Reactive (%)	Calculative (%)	Proactive (%)	Generative (%)	p-value
1	Information	Staff	0,00	1,40	1,80	8,00	88,9	0.741
		Manager	0,00	0,00	0,00	0,00	100,0	
2	Organizational Learning	Staff	0,00	0,60	1,60	5,60	92,2	0.840
		Manager	0,00	0,00	0,00	0,00	100,0	
3	Employee Participation	Staff	0,00	0,40	2,00	18,70	78,9	0.852
		Manager	0,00	0,00	0,00	10,00	90,0	
4	Communication	Staff	0,20	0,40	0,80	11,10	87,5	0.839
		Manager	0,00	0,00	0,00	0,00	100,0	
5	Commitment	Staff	0,00	0,60	1,20	6,20	92,0	0.834
		Manager	0,00	0,00	0,00	0,00	100,0	

Source: Primary Data

The implementation of health safety management system (SMS) implementation in the 10 petrochemical industries from document review and observation, a significant alignment with national and international standards. The data include company codes, year of establishment or start of operations, type of company ownership, production line category (plastic or non-plastic raw materials), safety documentation owned, and the specific safety systems implemented. The qualitative findings show that the sampled petrochemical plants have been in operation for over 25 years. Most of these companies have health safety and process safety documents in place to comply with national regulations. In addition, they implement international standards for process safety. The majority of the sampled companies are MNC and foreign investment enterprises. Based on production line similarity, the sample includes five plastic raw material producers and five non-plastic raw material producers.

All companies reported compliance with Indonesia's mandatory occupational health and safety standards, particularly the SMK3 (Occupational Health and Safety Management System) as stipulated by Ministerial Decree No. 308/2020 or Government Regulation No. 50/2012. In addition to SMK3, most companies also implemented ISO 45001, reflecting alignment with international occupational health and safety standards. Several companies also

adopted ISO 14001 (environmental management), ISO 9001 (quality management), or OHSAS 18001. These systems ensure a comprehensive approach to managing workplace hazards and improving health safety culture.

Regarding voluntary international safety systems, six companies had adopted the OSHA Process Safety Management (PSM) program, while three companies implemented the ILO PSM framework. Additionally, Responsible Care @Process Safety Code—a global initiative promoting chemical safety—was adopted by at least five companies, indicating a commitment to industry best practices in process safety. The multinational and foreign invested companies (e.g., PT NS, PT TM, PT CA) demonstrated broader adoption of both regulatory and voluntary international standards. This trend suggests that foreign ownership and global corporate policies may drive higher adherence to comprehensive safety frameworks. In contrast, while domestic companies (e.g., PT PI, PT PP) also comply with national regulations and some international standards, their safety systems tend to be more limited in scope.

DISCUSSION

Interpretation of Key Findings

This study explored the maturity of safety culture in ten petrochemical industries in Indonesia using a multi-dimensional framework. Most respondents rated their organizations at the "Generative" level across five safety culture dimensions: information, organizational learning, employee participation, communication, and commitment. This indicates a broadly embedded safety culture, consistent with established practices and regulatory compliance (13). In particular, the dimensions of communication and organizational learning scored highly, underscoring the importance of consistent messaging and managerial engagement in health safety (14,15). However, variations were noted when safety culture maturity was analyzed by company type (multinational vs. non-multinational). While most dimensions showed no significant difference, the commitment dimension stood out with a significant p-value ($p = 0.047$), suggesting that multinational corporations (MNC) may exhibit a higher degree of top-level dedication to health safety initiatives. This aligns with research indicating that MNC tend to invest more systematically in formalized health safety frameworks due to global corporate standards and investor expectations (16).

While this suggests a positive perception of safety culture, it is important to consider the limitations of self-reported data. These results provide insight into how safety culture maturity is perceived within Indonesia's petrochemical industry and point toward the need for more objective or triangulated assessment methods. Respondents, particularly managers may overestimate organizational maturity due to social desirability bias or overconfidence in current practices (17). While the majority of companies appear to have established a strong safety orientation, perception based on data should be complemented with audits, incident data, or behavioral observations to validate these claims (18). These findings may reflect aspirational rather than actual safety behaviors, suggesting a potential disconnect between perceived and practiced safety culture.

Nevertheless, this generally positive outlook must be interpreted with caution. Other studies have highlighted that the presence of structured systems or high maturity ratings may not always translate into effective implementation. That high self-reported safety culture maturity does not always correlate with actual safety performance, especially in multinational organizations where cultural differences can impact safety practices (19). Also, there may be underlying factors that could lead to discrepancies between perceived and actual safety practices (20,21). Similarlyin other studies found that organizations with formal safety systems sometimes scored highly on perception surveys despite having weak enforcement at the operational level (22). These findings point to the possibility of a disconnect between policy and practice especially when assessments rely solely on managerial perspectives or perception based on instruments (20).

When analyzed by role (staff vs. manager), the majority of both groups rated their organizations at the "Generative" level, with managers showing slightly higher ratings, often reaching 100% in several dimensions. However, none of these differences were statistically significant. This indicates a relatively uniform perception of health safety culture maturity across organizational hierarchies, though the higher ratings by managers may reflect greater exposure to strategic healthy safety planning or reporting bias (5,23). In terms of health safety system implementation, the documentary review of health safety documents revealed that all companies have adopted core standards such as SMK3 (as mandated by Indonesian regulations) and ISO 45001. A significant number also adopted international health safety practices like OSHA PSM, ILO PSM, and Responsible Care. The presence of these systems

reinforces the survey findings that most companies operate at a mature level of safety culture and have embedded regulatory and voluntary compliance mechanisms into their operational frameworks.

Several previous studies support these findings on the relationship between the adoption of formal health safety management systems and higher levels of safety culture maturity. The organizations implementing integrated health safety systems such as ISO 45001 showed significantly stronger health safety behaviors and cultural indicators, suggesting a direct link between system adoption and cultural maturity (3). Similarly, some research emphasized that the application of structured frameworks like OSHA PSM and ILO guidelines enhances organizational learning and risk perception, which are key components of a mature safety culture (24,25). Moreover, voluntary programs like Responsible Care contribute to sustained health safety improvement by fostering shared responsibility, transparency, and continuous evaluation across chemical industries (26). These studies align with our findings, confirming that the presence of both regulatory and voluntary systems reflects not only compliance but also a deeper organizational commitment to health safety excellence.

Comparison with Previous Studies

Our findings are consistent with prior research demonstrating that organizations with high safety culture maturity often implement standardized health safety protocols, promote continuous learning, and engage their workforce in safety practices (10,27,28) The high maturity levels observed here suggest that Indonesian petrochemical industries, especially those with international ties, have internalized these best practices. Similar trends were reported that emphasized the role of international certification and health safety training in enhancing cultural maturity (29). However, unlike studies that found substantial gaps between multinational and local companies (30), our results show only minor differences, with statistical significance noted solely in the Commitment dimension. This finding nuances the assumption that MNCs always outperform non-MNCs in all aspects of safety culture. It suggests that local companies in Indonesia may be catching up through the adoption of national standards like SMK3 and the increasing emphasis on regulatory compliance.

There were no significant differences found in safety culture maturity between companies handling plastic raw materials (BBP) and non-plastic materials. This supports findings who suggest that industry-specific hazards may not be the primary driver of safety maturity; rather, organizational commitment, systems integration, and leadership are more critical (31–33). The results reaffirm that maturity can be consistently achieved across industrial subtypes when health safety systems are rigorously implemented. Moreover, while other research indicated that communication and information sharing often vary widely across company types and sizes (34,35), our study found no significant differences in these dimensions. This implies that communication mechanisms in Indonesian petrochemical industries may be more uniformly structured, perhaps due to industry-specific hazards requiring mandatory communication protocols, regardless of company origin.

Limitations and Cautions

While the study provides valuable insights, several limitations must be acknowledged. First, the cross-sectional nature of the survey prevents us from establishing causality. We cannot ascertain whether the adoption of systems like ISO 45001 or OSHA PSM led to the perceived maturity, or whether companies with existing mature cultures were more likely to adopt such frameworks. Longitudinal studies are needed to explore these causal pathways. With self-reported survey data may be subject to social desirability or recall bias, especially in a health safety-sensitive industry(36). Managers may be inclined to over-report maturity to reflect well on their organizations. Although this was somewhat mitigated by including both staff and manager responses, the imbalance in sample size between the two roles (e.g., fewer managers) could affect comparative validity.

The documentation review, while thorough, did not assess the quality or implementation fidelity of the health safety systems. Merely possessing ISO certificates or SMK3 documents does not guarantee effective practice on the ground (37,38). Future research should triangulate document review with observational audits or third-party of health safety performance data to validate implementation effectiveness. This study focused on a relatively small sample of ten companies, limiting generalizability. While the companies selected represent a mix of multinational and national firms, and plastic vs. non-plastic raw material industries, the findings may not reflect conditions in smaller enterprises

or other industrial sectors. Broader studies incorporating additional regions and company sizes would help test the robustness of these findings.

Recommendations for Future Research

Future studies should investigate the role of cultural and organizational factors, such as leadership style, communication climate, and workforce empowerment, in shaping safety culture maturity as recommended byPei at al. (2023) (39). Integrating sociocultural dimensions into health and safety assessments, researchers could develop more targeted and context-sensitive strategies for fostering sustainable health safety culture improvements across Indonesia's industrial landscape.

CONCLUSION

This study investigated the maturity of safety culture implementation across Indonesia's petrochemical industry and aimed to assess how different company characteristics influence the adoption of key health safety culture dimensions. The findings demonstrated that most respondents perceived their safety culture at a "Generative" level, indicating strong implementation in areas such as commitment, organizational learning, and information. Statistical analysis revealed a significant difference only in the commitment dimension between multinational and non-multinational companies. Although other dimensions showed descriptive differences, these were not statistically significant. This highlights the need for closer examination of how organizational structures may influence safety culture perceptions and practices. While this study offers valuable insights into the current state of safety culture maturity, it has limitations, including its cross-sectional design, with self reported data, and a sample limited to petrochemical industry. Future research should employ longitudinal designs to track the maturity level. Additionally, qualitative methods should be used to evaluate the effectiveness of health and safety practices. Expanding research to include other high-risk industries would help inform the development of more specific context about health and safety management strategies and policies.

AUTHOR'S CONTRIBUTION STATEMENT

PNA contributed to the conceptualization of the study, data collection, data analysis, and manuscript writing. ZD was involved in the conceptualization, supervision of the research process, and critical review of the manuscript. AA supported data analysis and contributed to the writing of the manuscript. This statement provides clarity on the specific roles each author played in the research, ensuring transparency and accountability in the research process.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest, financial or otherwise, that could have influenced the outcomes or interpretation of this research. No external funding was received for this study. This statement affirms the integrity and objectivity of the research findings.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors disclose that AI-assisted technologies, specifically Grammarly, were used solely to support language refinement related to grammar and tense consistency. No generative AI tools were used for content creation or data interpretation. This disclosure is in accordance with ethical publication standards to ensure transparency and academic integrity.

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