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Comparison of Conventional and Technology-Based OHS Management Systems in the Chemical Industry

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ABSTRACT
The aim of this study is to analyse and contrast the effectiveness of conventional and technology-based occupational health and safety (OHS) management systems in safeguarding worker safety in the chemical sector in Makassar.The study employs a quantitative methodology with a comparative design, involving 60 participants, including OHS officers, production supervisors, process operators, and OHS managers. Data were gathered through a Likert-scale questionnaire, observations, interviews, and documentation, and subsequently analysed using descriptive and inferential statistics, including independent t-tests, Pearson's correlation, and simple linear regression. The results indicate that technology-based OSH systems have a higher level of effectiveness (mean = 4.13) compared to conventional systems (mean = 3.43). The independent t-test revealed a significant difference ($p < 0.05$). Correlation analysis showed a strong positive relationship between the implementation of OSH technology and risk management effectiveness ($r = 0.68$). The regression results also show that OSH technology accounts for 46% of the improvement in risk management effectiveness. This study's results show that to make workplaces safer, we need to use digital technologies like safety sensors, real-time monitoring systems, and data platforms. In conclusion, technology-based systems are better at managing risks than traditional systems because they are more adaptable, responsive, and accurate.

INTRODUCTION

Occupational safety and health (OHS) is a fundamental aspect of industrial management, particularly in high-risk sectors. The implementation of OHS aims to create a safe, healthy, and productive work environment for workers and minimize the potential for workplace accidents and occupational diseases. The OHS system is crucial to prioritize because, with proper implementation, workplace accidents can be minimized, ensuring that all company activities remain smooth and uninterrupted. In the modern industrial context, an OHS system serves not only as a regulatory obligation but also as a crucial part of an organization's risk management strategy to maintain

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operational sustainability and protect human resources (Umar & Arifin, 2025; Wulandari et al., 2024).

The chemical industry is categorized as a high-risk industry due to the use of hazardous chemicals, complex chemical reactions, and potential hazards such as fire, explosions, and exposure to toxic substances. These risks can have serious impacts on worker safety, the environment, and the continuity of company operations. Despite existing workplace safety regulations, cases of exposure to toxic substances still occur frequently. Therefore, safety risk management in the chemical industry requires a comprehensive and integrated OHS management system to identify potential hazards and systematically control them (Widajati, 2025; Nurcantika, Jaksa, & Lusida, 2025).

In practice, the implementation of an OHS management system has become standard across various industrial sectors through the adoption of various international regulations and standards. One widely used standard globally is the ISO 45001-based occupational health and safety management system, which provides a systematic framework for organizations to identify hazards, assess risks, and implement effective controls to improve occupational safety performance. Implementation of this standard has also been shown to improve regulatory compliance and build a stronger safety culture in the workplace (Aini et al., 2025).

An OHS management system is essentially designed to ensure that any potential hazards in the work environment can be systematically identified, analyzed, and controlled. This process includes hazard identification, risk assessment, risk control, and continuous monitoring and evaluation of occupational safety performance. By implementing a structured management system, organizations can reduce the likelihood of workplace accidents and improve the effectiveness of workplace safety management (Ramadhan & Pharmawati, 2025).

However, in practice, many companies still implement conventional OHS management systems. These conventional systems generally rely on manual procedures, paper-based documentation, and supervision conducted through periodic field inspections by occupational safety officers. This approach has several limitations, particularly in terms of reporting speed, the accuracy of safety data recording, and the ability to monitor work conditions in real time (Umar & Arifin, 2025).

The limitations of conventional OHS systems can impact the effectiveness of risk control in high-hazard industrial environments. Slow incident reporting and limited access to real-time safety data can hinder rapid decision-making in addressing potential workplace accidents. Furthermore, manual-based systems also pose a risk of human error in recording and analyzing safety data (Rizka Sofia, 2025).

Along with the development of digital technology and the Industry 4.0 concept, various industrial sectors have begun adopting digital technology in various operational aspects, including occupational safety and health management. This digital transformation enables the integration of various technologies such as the Internet of Things (IoT), safety sensors, big data analytics, and artificial intelligence to improve the effectiveness of occupational safety management systems (Putra et al., 2024).

The use of digital technology in OHS management systems is often referred to as the Safety 4.0 concept, an occupational safety approach that utilizes digital technology to enhance monitoring capabilities, risk analysis, and data-driven decision-making. Through this technological integration,

companies can monitor work conditions in real time, detect potential hazards earlier, and improve their response to emergency situations in the workplace (Putra et al., 2024).

In the chemical industry, the implementation of a technology-based OHS management system can be realized through various innovations, such as the use of hazardous gas detection sensors, early warning systems for potential chemical leaks, wearable safety devices for workers, and digital platforms for occupational safety data management. This technology enables companies to improve the accuracy of risk monitoring and accelerate decision-making in critical situations.

In addition to improving the effectiveness of risk control, technology-based OHS systems also offer benefits in terms of the efficiency of occupational safety data management. Digitizing OHS documents allows for faster, more accurate recording, reporting, and management of safety data, making it more accessible to various stakeholders within the organization (Rizka Sofia, 2025).

However, implementing a technology-based OHS management system also faces several challenges. These include the relatively high investment required for technology, the readiness of human resources to operate digital systems, and the integration of technology with existing safety procedures within the organization.

On the other hand, academic studies on OHS management systems have largely focused on the implementation of general safety standards without directly comparing the effectiveness of conventional and technology-based systems. Comparative research specifically analyzing the differences in effectiveness between these two approaches, particularly in the context of the chemical industry, remains relatively limited in the scientific literature (Umar & Arifin, 2025).

Although various studies have examined the implementation of occupational health and safety (OHS) management systems and their benefits in improving workplace safety, the majority of these studies still focus on the application of general standards such as ISO 45001 without conducting a comparative analysis between conventional and technology-based approaches. Furthermore, empirical studies specifically examining the effectiveness of digital technology integration within high-risk industries such as the chemical sector—particularly in Indonesia and at the operational level of companies—remain limited. This gap highlights the need for research that not only evaluates the implementation of OSH systems but also compares the effectiveness of these two approaches both quantitatively and contextually.

Based on this background, this study aims to analyze the differences in effectiveness between conventional and technology-based occupational health and safety management systems in the chemical industry, examine the correlation between the implementation of occupational health and safety technology and the effectiveness of occupational safety risk management, and determine the extent to which the implementation of occupational health and safety technology contributes to improving the effectiveness of occupational safety risk management.

METHODS

This study employs a quantitative approach with a comparative design, aiming to analyse the differences in effectiveness between conventional OSH management systems and technology-based OSH management systems within the context of the chemical industry. The research was conducted at a chemical plant in Makassar, involving 60 respondents selected using purposive sampling, namely individuals directly involved in the implementation of the OSH system in the

workplace. Respondents in this study comprised OSH officers (HSE), production supervisors, process operators, and OSH managers who possess an understanding of the occupational safety system implemented at the company.

Data collection was carried out using several techniques, namely the distribution of questionnaires, observation, structured interviews, and a document review. The questionnaire was designed using a Likert scale to measure respondents' perceptions of the effectiveness of conventional and technology-based OSH management systems, covering aspects of hazard identification, risk monitoring, the speed of incident reporting, and the accuracy of decision-making. Observations were carried out to obtain a direct picture of the implementation of the OSH system in the field, whilst interviews were used to gather more in-depth information regarding policies and constraints in the implementation of the OSH system. The document review involved examining company documents such as workplace accident reports and safety procedures.

The variables in this study consist of independent variables, namely the conventional OSH management system and the technology-based OSH management system, as well as a dependent variable, namely the effectiveness of occupational safety risk management. Prior to data analysis, the research instruments were first tested for validity and reliability. The validity test was conducted using Pearson's correlation with a criterion of a calculated r value greater than the table r value at a significance level of 0.05, whilst the reliability test used Cronbach's Alpha with a value of ≥ 0.70, indicating that the instruments possess a good level of consistency.

Data analysis was carried out in two stages: descriptive and inferential statistical analysis. Descriptive analysis was used to describe the characteristics of the respondents and the level of implementation of each OSH system. Subsequently, inferential analysis was carried out using the Independent Samples t-test to test the difference in means between the two systems, Pearson's correlation analysis to determine the relationship between the application of OSH technology and the effectiveness of risk management, and simple linear regression analysis to measure the extent of the influence of independent variables on the dependent variable. The entire data analysis process was carried out using SPSS statistical software.

RESULTS

1. Characteristics of Research Respondents

The following table shows the characteristics of respondents involved in the research based on job title in chemical industry companies.

Table 1. Distribution of Respondents by Position

No	Respondent's Position	Number (n)	Percentage (%)
1	K3 Officer / HSE Officer	15	25%
2	Production Supervisor	12	20%
3	Process Operator	23	38.3%
4	K3 Manager / Coordinator	10	16.7%
Total		**60**	**100%**

Based on Table 1, it can be seen that the majority of respondents in this study were process operators, as many as 23 people (38.3%), followed by OHS officers as many as 15 people (25%), production supervisors as many as 12 people (20%), and OHS managers or coordinators as many as

10 people (16.7%). This composition of respondents shows that the study involved various parties who have direct involvement in the implementation of the OHS management system in the chemical industry, so that the data obtained is considered quite representative to describe the conditions of the implementation of the occupational safety system in the company.

2. Descriptive Statistics of Conventional OHS Management System

Table 2. Descriptive Statistics of Conventional OHS Management System

No	Indicator	Mean	Standard Deviation	Category
1	Use of manual procedures in K3 management	3.45	0.72	Enough
2	Paper-based K3 documentation	3.62	0.68	Good
3	Periodic safety inspections	3.70	0.64	Good
4	Manual incident reporting system	3.28	0.75	Enough
5	Speed of response to potential hazards	3.10	0.80	Enough
	Overall average	**3.43**	**0.72**	**Quite Effective**

Based on the descriptive statistical analysis in Table 2, the conventional OHS management system had an average score of 3.43, which is considered quite effective. The indicator with the highest score was regular safety inspections (mean = 3.70), indicating that field supervision remains a key component of conventional occupational safety management.

However, the speed of response to potential hazards indicator (mean = 3.10) had the lowest score compared to the other indicators. This indicates that conventional OHS systems are limited in terms of speed of decision-making and response to potential risks because safety data reporting and processing are still done manually.

3. Descriptive Statistics of Technology-Based Occupational Health and Safety Management System

Table 3. Descriptive Statistics of Technology-Based Occupational Health and Safety Management System

No	Indicator	Mean	Standard Deviation	Category
1	Use of safety sensors and hazard detection	4.12	0.55	Good
2	Real-time safety monitoring system	4.18	0.52	Good
3	Digital platform for OHS data management	4.05	0.60	Good
4	Speed of incident reporting through digital systems	4.20	0.50	Very good
5	Safety data-driven decision making	4.10	0.58	Good
	Overall average	**4.13**	**0.55**	**Good**

The results of the descriptive statistical analysis in Table 3 show that the technology-based OHS management system had an average score of 4.13, which is considered good. The indicator with the highest score was the speed of incident reporting through the digital system (mean = 4.20), indicating that the use of technology can improve the efficiency of the occupational safety reporting

process.

In addition, the real-time safety monitoring system indicator (mean = 4.18) also shows a high value, which indicates that the use of technology such as safety sensors and digital monitoring systems can improve the company's ability to detect potential hazards more quickly and accurately.

4. Comparison of Descriptive Statistics of the Two K3 Systems

Table 4. Comparison of Average Values of OHS Management Systems

Occupational Health and Safety Management System	Mean	Standard Deviation
Conventional K3 System	3.43	0.72
Technology-Based Occupational Health and Safety System	4.13	0.55

Table 4 shows that technology-based OHS management systems have a higher average score than conventional OHS systems. The average score for technology-based OHS systems is 4.13, while the average score for conventional OHS systems is 3.43.

These differences in scores demonstrate that the application of digital technology in occupational safety management can improve the effectiveness of risk control in the chemical industry. Technology-based systems enable real-time monitoring of work conditions, expedite incident reporting, and support data-driven decision-making, thereby improving overall occupational safety performance.

5. Comparative Analysis Using Independent Sample t-test

To determine whether there is a significant difference between the effectiveness of conventional OHS management systems and technology-based OHS management systems in the chemical industry, an analysis was carried out usingIndependent Sample t-test. This analysis aims to compare the average of the two groups of research variables.

Table 5. Results of the Independent Sample t-test

Variables	Mean	Standard Deviation	t-count	Sig. (p-value)
Conventional OHS Management System	3.43	0.72		
Technology-Based Occupational Health and Safety Management System	4.13	0.55	5.62	0.000

Based on the results of the Independent Sample t-test in Table 5, the calculated t-value was 5.62 with a significance value (p-value) of 0.000, which is smaller than the significance level of 0.05. These results indicate that there is a significant difference between the conventional OHS management system and the technology-based OHS management system in managing occupational safety in the chemical industry.

The average effectiveness score for technology-based OHS management systems (mean = 4.13) was higher than that for conventional OHS management systems (mean = 3.43). This indicates that the application of digital technology in occupational safety systems contributes significantly to improving the effectiveness of occupational safety risk management. Technology-based systems enable more accurate monitoring of working conditions, accelerate the incident reporting process, and enhance the company's ability to detect potential hazards early.

6. Correlation Analysis between the Implementation of OHS Technology and the Effectiveness of Risk Management

To determine the relationship between the application of occupational safety technology and the effectiveness of occupational safety risk management, an analysis was conducted using Pearson correlation.

Table 6. Correlation Analysis Results

Variables	Correlation Coefficient (r)	Sig. (p-value)
Implementation of K3 Technology – Effectiveness of Risk Management	0.68	0.000

The results of the correlation analysis show a correlation coefficient (r) of 0.68 with a significance value of 0.000 (<0.05). This indicates a positive and significant relationship between the implementation of occupational safety technology and the effectiveness of occupational safety risk management in the chemical industry.

A strong correlation indicates that the higher the level of technology implementation in the OHS management system, the higher the effectiveness of occupational safety risk management in the company. The implementation of technologies such as safety sensors, digital monitoring systems, and safety data management platforms allows companies to improve the accuracy of hazard identification and accelerate decision-making in situations that have the potential to lead to workplace accidents.

7. Linear Regression Analysis

To determine how much influence the application of occupational safety technology has on increasing the effectiveness of occupational safety risk management, an analysis was carried out using simple linear regression.

Table 7. Linear Regression Analysis Results

Variables	Regression Coefficient (β)	t-count	Sig.
Constant	1.52	3.45	0.001
Implementation of K3 Technology	0.64	7.18	0.000

Coefficient of Determination

R	R^2	Adjusted R^2
0.68	0.46	0.45

The results of the regression analysis show a regression coefficient of 0.64 with a significance level of 0.000 (<0.05). This indicates that the implementation of occupational safety technology has a positive and significant impact on increasing the effectiveness of occupational safety risk management in the chemical industry.

In addition, the coefficient of determination (R^2) value of 0.46 shows that 46% of the variation in the effectiveness of occupational safety risk management can be explained by the application of occupational safety technology, while the remaining 54% is influenced by other factors outside the research variables, such as occupational safety culture, worker competency level, management leadership, and compliance with occupational safety procedures.

Journal of Occupational Safety, Health, and Environmental Management (K3)
Vol. 01, No. 1, February 2026

Overall, the results of this analysis indicate that the integration of digital technology into the OHS management system can make a significant contribution to increasing the effectiveness of occupational safety risk management in the chemical industry.

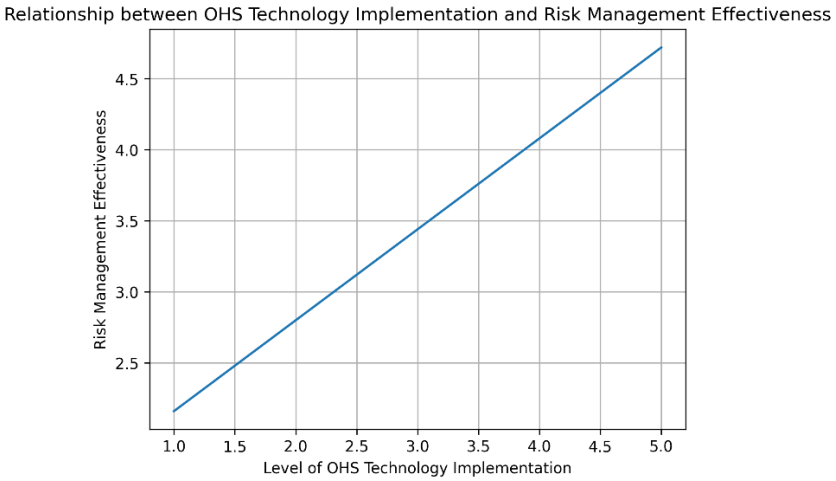

Figure 1. Relationship between OHS Technology Implementation and Risk Management Effectiveness

The graph illustrates a positive linear relationship between the level of OSH technology implementation (X-axis) and risk management effectiveness (Y-axis). The regression line shows a positive slope ($\beta = 0.64$), indicating that any increase in the implementation of OSH technology is followed by an increase in the effectiveness of occupational safety risk control.

Conceptually, this visualisation reinforces the results of the regression analysis in Table 7, where the integration of technologies such as safety sensors, real-time monitoring systems, and digital platforms contributes to enhancing an organisation's ability to identify, monitor, and control risks more quickly and accurately.

DISCUSSION

1. Comparison of the Effectiveness of Conventional and Technology-Based OHS Management Systems

The research results show that technology-based OHS management systems have a higher level of effectiveness compared to conventional OHS systems. This is demonstrated by the higher average effectiveness score of technology-based systems compared to conventional systems. These findings demonstrate that integrating digital technology into occupational safety systems can improve the quality of occupational safety risk management in the chemical industry.

Conceptually, an effective occupational safety management system relies heavily on an organization's ability to systematically identify hazards, monitor working conditions, and control risks. Conventional occupational safety systems generally rely on manual procedures such as paper-based documentation and periodic field inspections, slowing down the collection and analysis of occupational safety data. These limitations can reduce an organization's ability to respond quickly to potential hazards, particularly in high-risk industrial sectors like the chemical industry.

In contrast, a technology-based OHS management system enables companies to monitor working conditions in real time through the use of digital technologies such as safety sensors,

industrial CCTV, and software-based monitoring systems. Implementing this technology can increase the effectiveness of occupational safety oversight and accelerate the process of identifying potential hazards in the workplace (Dongoran & Dwi Nugroho, 2025).

The results of this study also align with research showing that the systematic implementation of an occupational safety and health management system (SMK3) can improve occupational safety levels and reduce the risk of workplace accidents in the industrial sector. A sound SMK3 implementation enables companies to manage safety risks in a more structured manner through hazard identification, risk assessment, and ongoing risk control (Febriyanti et al., 2024).

The researchers assume that the increased effectiveness of technology-based occupational health and safety management systems is not solely determined by the presence of digital devices, but rather results from the synergy between comprehensive system integration, organisational readiness, and workers' levels of technological literacy. Thus, technology acts as an enabler whose effectiveness is highly dependent on institutional capacity and the quality of human resources in operating and optimising the system. The findings of this study are consistent with previous studies showing that digitalisation can improve occupational safety performance; however, this study makes an additional contribution through a direct comparative approach between conventional and technology-based systems, which is still relatively rare in the literature, particularly in the context of the chemical industry.

From a mechanistic perspective, the increased effectiveness of technology-based systems can be explained through several key processes, namely the ability of automation to detect potential hazards at an early stage, the reduction of human error through standardised systems, the availability of real-time data that supports rapid responses to risks, and more accurate and objective data-driven decision-making. Nevertheless, the implementation of technology-based systems also faces a number of practical and contextual limitations, including high initial investment requirements, limited readiness of human resources to adopt new technologies, resistance to organisational change, and the uneven distribution of digital infrastructure across various industrial sectors. Therefore, the successful implementation of technology within OSH systems requires a holistic approach that focuses not only on technical aspects but also takes into account organisational and social dimensions comprehensively.

2. Significant Differences between Conventional OHS Systems and Technology-Based OHS Systems

Statistical analysis results show significant differences between conventional OHS management systems and technology-based OHS systems in managing occupational safety in the chemical industry. These differences demonstrate that the use of digital technology in occupational safety systems can significantly contribute to improving the effectiveness of occupational safety risk control.

This significant difference can be explained through the perspective of occupational safety risk management, which emphasizes the importance of a continuous risk monitoring and control system. In conventional systems, occupational safety oversight is often carried out manually through periodic inspections by occupational safety officers. This approach has limitations in terms of the speed of hazard detection and the accuracy of occupational safety data collection.

In contrast, a technology-based OHS system enables companies to monitor working conditions more quickly and accurately through the use of digital technology. This technology can help companies detect potential hazards early and improve the effectiveness of occupational safety oversight in industrial environments.

Previous research has shown that optimal implementation of an OHS management system can positively impact occupational safety performance and the successful implementation of safety programs within a company. A structured OHS system can improve compliance with occupational safety procedures and strengthen a safety culture in industrial environments (David et al., 2026).

In addition, other studies also show that implementing occupational safety and health management system policies can help companies reduce workplace accident rates through more systematic risk control (Fipiana et al., 2024).

Based on these results, it can be assumed that technology plays a supporting role in increasing the effectiveness of the implementation of an OHS management system. However, the success of implementing an occupational safety system depends not only on technology but also on organizational factors such as management commitment and worker compliance with occupational safety procedures.

3. The Relationship between the Implementation of OHS Technology and the Effectiveness of Risk Management

The results of the correlation analysis indicate a strong positive relationship between the implementation of occupational safety technology and the effectiveness of occupational safety risk management. This finding suggests that the higher the level of technology implementation in the OHS management system, the higher the effectiveness of occupational safety risk management in the company.

Theoretically, occupational safety technology plays a crucial role in enhancing an organization's ability to continuously monitor working conditions. The use of digital technology enables companies to collect and analyze occupational safety data more accurately, allowing for faster identification of potential hazards.

Previous research has shown that the use of digital technology in occupational safety systems can increase the effectiveness of occupational safety monitoring and accelerate the decision-making process in controlling occupational safety risks in companies (Putriwardani & Susilawati, 2024).

Furthermore, other research shows that risk management within an OHS management system is significantly influenced by the effectiveness of the risk identification and monitoring process in the workplace. Implementing a sound OHS management system can help companies identify various potential hazards and significantly reduce the risk of workplace accidents (Palik et al., 2024).

The researchers believe that the synergy between thorough system integration, organisational preparedness, and employees' levels of technological literacy accounts for the greater efficacy of technology-based occupational health and safety management systems rather than just the existence of digital devices. In order to operate and optimise the system, technology serves as an enabler whose efficacy is mostly dependent on institutional capability and the calibre of human resources. The results of this study are in line with earlier research demonstrating that digitalisation

can enhance occupational safety performance. Nevertheless, this study adds something new by directly comparing conventional and technology-based systems, which is still comparatively uncommon in the literature, especially when it comes to the chemical industry.

From a mechanistic standpoint, the increased efficacy of technology-based systems can be explained by a number of important processes, including automation's capacity to identify possible risks early on, standardised systems' ability to reduce human error, real-time data availability that facilitates quick responses to risks, and more precise and objective data-driven decision-making. However, there are a number of contextual and practical obstacles to the adoption of technology-based systems, such as the unequal distribution of digital infrastructure across different industrial sectors, resistance to organisational change, high initial investment requirements, and human resources' limited readiness to adopt new technologies. Therefore, a complete strategy that considers organisational and social factors in addition to technical ones is necessary for the successful integration of technology inside OSH systems.

4. The Impact of the Implementation of K3 Technology on the Effectiveness of Risk Management

The results of the regression analysis indicate that the implementation of occupational safety technology has a positive influence on the effectiveness of occupational safety risk management in the chemical industry. The coefficient of determination indicates that some of the variation in the effectiveness of occupational safety risk management can be explained by the implementation of occupational safety technology.

These findings demonstrate that technology plays a critical role in supporting the implementation of more effective occupational safety management systems. Technology enables companies to improve the quality of occupational safety monitoring and accelerate the decision-making process in managing occupational safety risks.

However, the results of this study also indicate that other factors influence the effectiveness of occupational safety risk management besides technology. These factors include occupational safety culture, worker competence, and management commitment to consistently implementing occupational safety systems.

Previous research shows that the successful implementation of occupational safety programs is greatly influenced by the integration between the OHS management system, occupational safety culture, and worker involvement in implementing occupational safety procedures in the company (Cantika & Sofyan, 2024).

Thus, the results of this study indicate that the implementation of occupational safety technology should not be implemented in isolation but rather integrated with strategies to strengthen occupational safety culture and improve worker competency. This approach will enable companies to optimize the benefits of technology in improving the effectiveness of occupational safety management systems in the chemical industry.

CONCLUSIONS

This study finds evidence for the significantly higher effectiveness of technology-oriented occupational health and safety (OHS) management systems than traditional ones in enhancing the performance of occupational safety risk management in chemical industry. In support, the findings

from testting point out that technology application accounts for 46% to the attainment of the improvement on effectiveness level of the system, wrapping up along with a directionor strategic objective that digitalization will formalize an industrialized solution towards a more adaptable, responsive and data-driven occupational health safety system at contemporary time. Nevertheless, several limitations must be kept in mind when interpreting the findings of this study. First, the results may not be generalisable due to limited sample size in one region (Makassar). Second, the research variables do not consider key organisation factors such as safety culture and leadership which have been shown in the literature to strongly impact OSH effectiveness on implementation. Thirdly, the use of a cross-sectional research design has not been able to capture the dynamics of change and the long-term sustainability of the system's effectiveness. As a result, future studies should focus on longitudinal research to explore the changing time dynamics underlying system effectiveness, organizational variables such as safety culture and leadership into the analytical model, and wider industrial domains in order to improve external validity and generalisability.

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