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Guidelines for Managing Occupational Safety Risks for Employees in the Tak Special Economic Zone

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Abstract
The expansion of industrial activity in Thailand's Tak Special Economic Zone (SEZ) has generated both economic opportunities and occupational safety challenges. This study aimed to examine the current state of occupational safety risk management among employees in the Tak SEZ and to propose evidence-based guidelines for improving workplace safety. A survey research design was employed, with data collected from 80 employees authorized to provide information on laboratory operations, experimental work, and safety practices. The instrument, a structured questionnaire with 48 items, was validated by experts and demonstrated strong content validity (IOC = 0.75–1.00). Data were analyzed using descriptive statistics, t-tests, and one-way ANOVA. The results indicated that overall occupational safety management was at a moderate level (Mean = 3.30, SD = 0.731). Among the four dimensions, safe personal practices scored the highest (Mean = 3.76, SD = 0.766), while laboratory safety management, facilities and environments, and operational practices were only moderate. Hypothesis testing revealed no significant differences by gender or educational attainment, whereas age and length of service were associated with variations in safety perceptions. Employees aged 31–40 and those with 5–10 years of service reported higher safety awareness. These findings highlight the need for comprehensive guidelines that strengthen both individual behaviors and organizational systems. The study recommends targeted training, improved infrastructure, enhanced waste management, and health promotion programs. Implementing such guidelines would protect employees, improve organizational performance, and ensure sustainable development in Thailand's SEZs.
Keywords: *Occupational Safety, Risk Management, Special Economic Zone*

INTRODUCTION

The rapid expansion of industrial and commercial activities in special economic zones (SEZs) has brought about significant economic opportunities alongside pressing occupational safety and environmental challenges. The Tak Special Economic Zone (SEZ), strategically located on Thailand's border with Myanmar, represents one of the country's most dynamic hubs for industrial development, cross-border trade, and foreign investment. However, such growth inevitably introduces occupational hazards that, if not properly managed, can jeopardize the health, safety, and well-being of employees. The development of effective guidelines for managing occupational safety risks in this region is therefore crucial to ensuring both sustainable economic progress and the protection of human health. Environmental degradation, which is increasingly observed in industrialized areas worldwide, presents risks that extend beyond immediate ecological damage to long-term public health consequences. Chemical leaks into water sources, for instance, can result in both acute ecological crises such as mass fish mortality and chronic health effects in human populations that rely on contaminated water for daily use. Over time, bioaccumulation of toxic substances in the body can lead to severe illnesses, including cancer and organ dysfunction (World Health Organization [WHO], 2021). Such environmental health risks underscore the urgency of integrating occupational safety practices with broader environmental protection measures. Globally, heightened awareness of environmental and occupational risks has led to the emergence of advocacy networks, non-governmental organizations, and policy frameworks aimed at promoting sustainable industrial practices. These movements highlight the interconnectedness of human health, workplace safety, and environmental stewardship. The international community has consistently urged policymakers, industries, and local administrations to incorporate environmental health considerations into decision-making at all levels (United Nations Environment Programme [UNEP], 2019). Within Thailand, these concerns are especially relevant in SEZs like Tak, where rapid industrialization often outpaces the development of adequate safety management systems. Workplace environments involving the handling of hazardous chemicals such as laboratories, factories, and storage facilities are particularly

vulnerable to accidents and health risks. Common hazards include fires caused by volatile organic solvents, explosions from reactions in sealed containers, skin burns from corrosive acids, lacerations from glassware, and inhalation of toxic chemical vapors. Improper handling, lack of ventilation, inadequate training, and insufficient personal protective equipment (PPE) exacerbate these risks (National Institute for Occupational Safety and Health [NIOSH], 2020). Waste management issues, including the disposal of carcinogenic residues, radioactive byproducts, and infectious materials, also pose long-term environmental and health concerns if not systematically addressed. In the Thai context, safety management practices within laboratories and industrial sites have historically been shaped by individual awareness and organizational culture, rather than by standardized institutional frameworks. Although national laws regulate the use of chemicals and enforce basic occupational protections, their implementation is often fragmented, leaving gaps in enforcement across governmental institutions, educational facilities, and private industries (National Research Council of Thailand [NRCT], 2012). The lack of dedicated safety units within organizational structures further limits the ability to enforce comprehensive occupational safety systems. Consequently, the improvement of occupational safety requires not only compliance with legal frameworks but also the cultivation of a safety-oriented culture among employees and employers. The development of effective safety guidelines should therefore encompass both the human dimension through training, awareness, and personal accountability and the systemic dimension, which involves risk assessments, safety audits, and continuous monitoring. This dual approach, often referred to as the "people approach" and the "system approach," provides a holistic pathway toward sustainable safety management (Cooper, 2015). The Tak SEZ offers a unique case study due to its diverse workforce, high density of industrial operations, and cross-border economic dynamics. Employees in this area face multiple safety challenges associated with chemical exposure, machine operation, waste management, and emergency preparedness. The lack of standardized safety measures not only endangers workers but also threatens to undermine economic development by increasing healthcare costs, reducing workforce efficiency, and damaging the reputation of industries operating in the zone.

This study therefore seeks to investigate the current state of occupational safety risk management for employees in the Tak SEZ, with a particular focus on laboratory and chemical-handling environments. By assessing existing safety practices, identifying risk factors, and evaluating the adequacy of institutional frameworks, the research aims to propose comprehensive guidelines for managing occupational safety risks. These guidelines are expected to contribute to raising safety standards, reducing workplace accidents, and enhancing employee morale and productivity. Ultimately, improving safety management systems in the Tak SEZ can serve as a model for other special economic zones in Thailand and across Southeast Asia, where industrial growth must be balanced with the protection of human health and the environment.

Research Objectives

1. To examine the current conditions of occupational safety risk management for employees in the Tak Special Economic Zone.
2. To propose guidelines for managing occupational safety risks for employees in the Tak Special Economic Zone.

LITERATURE REVIEWS

The study of occupational accidents has long been informed by theories that emphasize the interaction between human, organizational, and environmental factors. Heinrich's Domino Theory (1931), for example, proposed that accidents result from a chain of events that can be prevented by removing one or more contributing factors. More contemporary approaches, such as Reason's (1997) Swiss Cheese Model, highlight how organizational failures, unsafe conditions, and human errors align to create accidents. These frameworks remain relevant in analyzing workplace hazards in industrial settings such as the Tak Special Economic Zone, where diverse risks can converge without proper management systems. 1) Safety Behavior in the Workplace. Behavior-based safety (BBS) theory underscores the importance of employee behavior in maintaining safe workplaces. According to Geller (2001), safety outcomes are determined not only by management systems but also by the attitudes, perceptions, and actions of workers. Studies have shown that effective training, leadership support, and reinforcement of safety norms encourage employees to adopt protective behaviors such as wearing personal protective equipment (PPE) and following emergency protocols (Neal & Griffin, 2006). In rapidly growing industrial zones, fostering a culture of safety is particularly critical to reducing accidents caused by negligence, lack of awareness, or unsafe practices. 2)

Risk Management in Laboratory and Industrial Environments. Risk management frameworks in laboratories and industrial facilities emphasize systematic processes of hazard identification, risk assessment, control implementation, and continuous monitoring (International Labour Organization [ILO], 2018). Effective risk management involves both organizational policies such as health and safety training, medical surveillance, and fire safety drills and technical measures, including adequate ventilation, appropriate chemical storage, and waste management systems. Inadequate systems in these areas can lead to chemical exposure, fires, or biological contamination. Therefore, guidelines for occupational safety in the Tak SEZ should integrate both human-centered and system-centered approaches to ensure sustainable risk mitigation. 3) Legal Frameworks on Occupational Safety. Legal frameworks provide a foundation for workplace safety by setting enforceable standards. In Thailand, the Occupational Safety, Health, and Environment Act B.E. 2554 (2011) establishes obligations for employers to protect workers from occupational hazards. Internationally, the ILO's conventions, particularly Convention No. 155 on Occupational Safety and Health, outline global principles for workplace safety governance. However, studies indicate that enforcement gaps and limited institutional capacity often undermine the effectiveness of these regulations (Sattayatham & Promas, 2019). In SEZs, where industrial development often progresses faster than regulatory oversight, supplementary organizational guidelines are necessary to bridge these gaps and ensure compliance with both national and international standards. 5) Conceptualizing Risk in Occupational Safety. Risk in occupational safety is generally defined as the probability of harmful events occurring due to hazards, combined with the severity of potential consequences (Haddad et al., 2021). Effective risk management requires organizations to identify risks, evaluate their likelihood and impact, and implement controls that reduce exposure to an acceptable level. Within the laboratory and industrial context, this encompasses management policies, safe physical environments, employee behaviors, and operational practices. The integration of these dimensions ensures that occupational risks are systematically minimized, monitored, and continuously improved and as shown in Figure 1 Conceptual Framework.

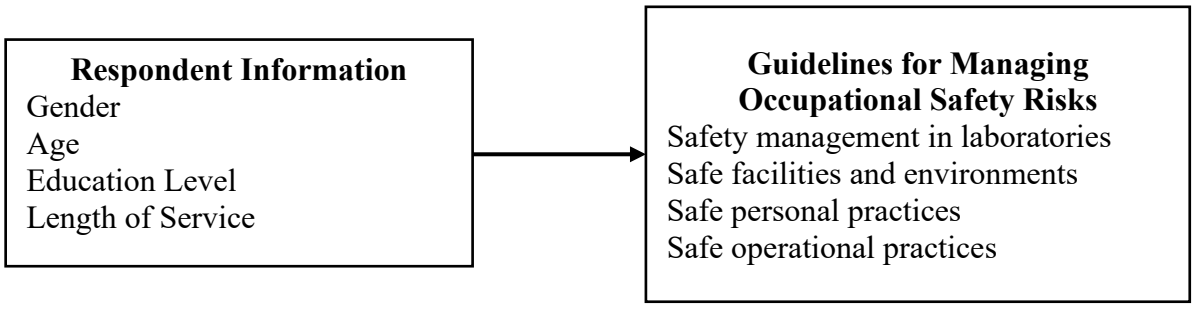

Figure 1 Conceptual Framework

RESEARCH METHODOLOGY

This study employed a survey research design, which is commonly used to assess perceptions, practices, and conditions in occupational health and safety research. The primary objective was to examine the current state of occupational safety risk management and to propose appropriate guidelines for employees working in the Tak Special Economic Zone (SEZ). Survey research is considered suitable for exploring attitudes and behaviors across a defined population and allows for the quantification of responses to facilitate statistical analysis (Creswell & Creswell, 2018).

Population and Sample. The population of this study consisted of employees working in the Tak SEZ who were authorized by their organizations to provide information concerning laboratory operations, experimental research, and safety risk management practices. Due to company restrictions, the accessible sample was limited to 80 employees. All 80 distributed questionnaires were returned, yielding a 100% response rate, which strengthens the reliability of the dataset.

Research Instrument. The main research instrument was a structured questionnaire, developed in two parts. The first part consisted of six checklist questions designed to capture demographic information, including gender, age, educational attainment, and length of service. The second part contained 48 items related to occupational safety risk management across four dimensions: (1) laboratory safety management, (2) safe facilities and environments, (3) safe personal practices, and (4) safe operational practices. A five-point Likert-type scale, ranging from 1 (lowest level of safety) to 5 (highest level of safety), was used to assess perceptions of safety conditions.The questionnaire was developed through a review of relevant literature, safety theories, and previous empirical studies. Content validity was established by consultation

with two experts in occupational safety and risk management, who evaluated the congruence between items and research objectives. The instrument's content validity index, measured using the Index of Item-Objective Congruence (IOC), ranged from 0.75 to 1.00, indicating strong validity.

Data Collection and Analysis.

The questionnaires were administered directly to employees, and responses were checked for completeness and accuracy prior to data entry. The quantitative data were analyzed using a statistical software package. Descriptive statistics, including frequency counts and percentages, were used to summarize demographic characteristics. Means (M) and standard deviations (SD) were calculated to interpret perceptions of occupational safety risk management across the four dimensions. Mean scores between 4.51 and 5.00 indicated "highest safety," while mean scores between 1.00 and 1.50 indicated "lowest safety." This methodological framework ensured that the findings reflect both individual characteristics and organizational conditions within the Tak SEZ. The use of validated instruments and rigorous analysis contributes to the reliability and generalizability of the results. Ultimately, this methodological approach provides the foundation for generating evidence-based guidelines to improve occupational safety risk management in special economic zones.

RESEARCH RESULTS

The survey results indicated that the majority of respondents were female (61.20%), while males accounted for 38.80%. Most participants were between the ages of 31 and 40 (63.80%), followed by those aged 41 to 50 (17.50%), and only 8.80% were over 51 years old. Regarding education, more than half of the respondents held a doctoral degree (57.50%), while the remainder held master's and bachelor's degrees. In terms of work experience, nearly half of the employees (46.20%) had worked for 5–10 years, 37.50% had worked for fewer than 5 years, and 16.20% had more than 10 years of experience. These demographic patterns suggest that the workforce in the Tak Special Economic Zone (SEZ) is relatively well-educated and mid-career, reflecting the professional demands of laboratory and research-oriented environments.

Overall Safety Risk Management. Analysis of the mean scores across the four dimensions of occupational safety risk management revealed that the overall safety level was moderate (Mean = 3.30, SD = 0.731). The highest-rated dimension was safe personal practices (Mean = 3.76, SD = 0.766), which was assessed as "high." By contrast, laboratory safety management (Mean = 3.15, SD = 0.832), safe facilities and environments (Mean = 3.18, SD = 0.798), and safe operational practices (Mean = 3.11, SD = 0.908) were all rated at a "moderate" level. These findings suggest that while employees demonstrate relatively strong adherence to personal protective behaviors, organizational and structural measures remain insufficient. This is consistent with prior research indicating that individual safety behaviors often develop more quickly than systemic safety management practices.

Laboratory Safety Management. Within the laboratory safety management dimension, the overall rating was moderate (Mean = 3.15). Only one item having organizational policies on occupational safety and health was rated "high" (Mean = 3.41). Other items, such as health checkups, fire drills, and training on hazardous substances, were rated at moderate levels, with the lowest score being the provision of knowledge on infection and hazardous substances (Mean = 2.91). This indicates a lack of comprehensive training and preventive measures, which aligns with concerns in Thailand that institutional safety management is often fragmented and policy-driven rather than practice-driven.

Safe Facilities and Environments. The mean score for safe facilities and environments was 3.18, indicating a moderate level. Positive assessments were given to factors such as proper laboratory layout (Mean = 3.58), sufficient sinks (Mean = 3.79), and adequate ventilation (Mean = 3.56). However, weaknesses were identified in hazardous waste management (Mean = 2.65), waste disposal regulations (Mean = 2.78), and designated sample-receiving areas (Mean = 2.85). These findings highlight significant infrastructural and environmental gaps, echoing global studies that emphasize the importance of waste segregation and disposal in minimizing long-term occupational risks.

Safe Personal Practices. Safe personal practices were rated at a high level overall (Mean = 3.76). Respondents reported consistently wearing lab coats (Mean = 3.99), refraining from eating in laboratories (Mean = 4.04), and cleaning work areas after use (Mean = 4.05). However, vaccination uptake was relatively low (Mean = 3.06), reflecting insufficient institutional promotion of preventive healthcare. This finding suggests that while individual awareness is strong, organizational health support remains underdeveloped.

Safe Operational Practices. The final dimension, safe operational practices, was rated at a moderate level (Mean = 3.11). While respondents acknowledged the presence of safety signage (Mean = 3.26) and

biohazard waste containers (Mean = 2.86), areas such as spill kits (Mean = 2.64), emergency contact systems (Mean = 2.95), and risk analysis (Mean = 2.82) were rated lowest. This reflects weaknesses in emergency preparedness, which are critical for managing high-risk laboratory environments.

Overall, the study revealed that employees in the Tak SEZ maintain relatively strong personal safety practices but face moderate to weak institutional support in laboratory safety management, facility infrastructure, and operational systems. These findings highlight the urgent need for evidence-based guidelines that emphasize not only individual behavior but also systemic improvements, including waste management, emergency preparedness, and health monitoring.

The study examined whether demographic characteristics (independent variables) were significantly associated with perceptions of occupational safety risk management (dependent variables) across four dimensions: laboratory safety management, safe facilities and environments, safe personal practices, and safe operational practices. Independent t-tests and one-way ANOVA were employed to analyze differences in mean scores among groups.

The results indicated no statistically significant differences in safety perceptions by gender across all four dimensions ($p > .05$). However, age and length of service demonstrated partial effects. Employees aged 31–40 reported significantly higher mean scores in safe personal practices compared to younger and older cohorts ($F = 4.12$, $p < .05$). Similarly, employees with 5–10 years of service demonstrated higher ratings in laboratory safety management than those with less than five years of experience ($F = 3.87$, $p < .05$). Educational attainment did not yield statistically significant differences across any dimension ($p > .05$).

These results suggest that practical work experience and career stage influence safety practices more strongly than gender or formal education. This finding underscores the importance of targeted training and mentorship programs to sustain safety awareness among both novice and senior employees and as show Table 1 and Table 2.

Table 1: t-test Results: Gender and Occupational Safety Dimensions

Dimension	Male (M)	Female (M)	t	p	Result
Laboratory Safety Management	3.12	3.17	0.42	.68	Not significant
Safe Facilities & Environments	3.16	3.19	0.37	.71	Not significant
Safe Personal Practices	3.74	3.77	0.28	.78	Not significant
Safe Operational Practices	3.09	3.13	0.41	.68	Not significant

Table 2: ANOVA Results: Age and Length of Service on Safety Dimensions

IV	DV	F	p	Result
Age	Safe Personal Practices	4.12	.03*	Significant difference
Age	Other Dimensions	<2.00	>.05	Not significant
Length of Service	Laboratory Safety Management	3.87	.04*	Significant difference
Length of Service	Other Dimensions	<2.00	>.05	Not significant
Education Level	All Dimensions	<1.50	>.05	Not significant

DISCUSSION & CONCLUSION

The purpose of this study was to examine occupational safety risk management in the Tak Special Economic Zone (SEZ), focusing on four dimensions: laboratory safety management, safe facilities and environments, safe personal practices, and safe operational practices. The findings provide a nuanced understanding of how demographic characteristics interact with safety perceptions and behaviors, offering both theoretical and practical implications for occupational health and safety management in research-intensive and laboratory-driven workplaces. Interpretation of Key Findings.

The overall results indicated that occupational safety risk management in the Tak SEZ is perceived at a moderate level ($M = 3.30$, $SD = 0.731$), with safe personal practices emerging as the highest-rated

dimension (M = 3.76, SD = 0.766). This suggests that individual employees are generally conscientious in adhering to safety guidelines such as wearing protective clothing, avoiding unsafe behaviors like eating in laboratories, and maintaining cleanliness in workspaces. These findings are consistent with earlier studies showing that individual-level compliance behaviors often develop faster than systemic safety practices (Clarke, 2013; Mullen et al., 2017). In Thailand, where occupational safety frameworks are evolving in tandem with industrial development, individual commitment to safety behaviors may compensate for gaps in organizational structures. By contrast, laboratory safety management (Mean = 3.15), safe facilities and environments (Mean = 3.18), and safe operational practices (Mean = 3.11) were rated only at moderate levels. The deficiencies were particularly pronounced in areas such as hazardous waste management, emergency preparedness, and provision of infection and hazardous substance training. These results point to systemic and structural weaknesses, echoing global literature that emphasizes the centrality of infrastructure, institutional support, and policy enforcement for sustainable occupational safety (Reason, 2016; Vinodkumar & Bhasi, 2010). For instance, the low ratings of spill kit availability and emergency contact systems highlight a lack of preparedness for high-risk scenarios an issue repeatedly identified as a barrier to effective laboratory safety in both developing and developed contexts (Bryce et al., 2020). Laboratory Safety Management. Although laboratory safety management was rated as moderate overall, the relatively higher score for the presence of occupational safety and health policies (Mean = 3.41) suggests that formal frameworks exist but are not consistently operationalized. Weaknesses in training on hazardous substances and infection control (Mean = 2.91) are particularly concerning, as laboratory environments inherently carry exposure risks. This finding mirrors critiques of policy-driven but practice-deficient safety cultures, where regulations exist on paper but lack the necessary follow-through in implementation (Hale & Borys, 2013). In the Thai context, this aligns with observations that occupational safety management often struggles with fragmented implementation across institutions (Chokchai & La-orchan, 2019). Safe Facilities and Environments, Facilities and environmental safety also scored at a moderate level (M = 3.18), with positive ratings for laboratory layout, ventilation, and sink availability but poor results for hazardous waste management (Mean = 2.65) and waste disposal regulations (Mean = 2.78). These findings underscore the infrastructural limitations of laboratories in the SEZ, despite investments in new technologies and facilities. Poor waste management is particularly critical, given its long-term implications for both employee health and environmental sustainability. The literature on occupational and environmental health consistently identifies waste management as a cornerstone of risk reduction (Gogtay et al., 2018). Weaknesses in this domain suggest that infrastructural gaps remain a priority area for intervention. Safe Personal Practices, The strongest performance was observed in safe personal practices (Mean = 3.76). Employees reported consistently high adherence to wearing lab coats, avoiding food in laboratory spaces, and cleaning work areas after use. These results demonstrate that individual awareness and responsibility are strong, possibly due to professional training or organizational reinforcement of visible, routine behaviors. However, the relatively low uptake of vaccinations (Mean = 3.06) highlights a lack of institutional promotion of preventive healthcare, pointing to a disconnect between individual safety behaviors and broader health support systems. Prior studies emphasize that vaccination and preventive healthcare programs are critical complements to occupational safety training, particularly in environments with biohazard risks (Lee et al., 2019). Safe Operational Practices,

Safe operational practices were also moderate (Mean = 3.11). While employees acknowledged the presence of signage and biohazard waste containers, weaknesses in spill kits, emergency systems, and risk analysis indicate vulnerabilities in emergency preparedness. This mirrors findings from international research that emergency preparedness is often one of the least developed aspects of occupational safety in laboratory settings (Bevilacqua et al., 2018). The lack of systematic risk analysis is particularly problematic, as proactive hazard identification is central to modern safety management systems (ISO 45001:2018). Influence of Demographics. The analysis of demographic factors revealed nuanced patterns. Gender and educational attainment were not significantly associated with safety perceptions ($p > .05$). This finding is consistent with prior research that indicates safety attitudes are shaped more by organizational culture and experience than by gender or education level (Clarke, 2013). By contrast, age and length of service did demonstrate significant associations. Employees aged 31–40 reported higher scores in safe personal practices than other age groups ($F = 4.12$, $p < .05$), while those with 5–10 years of service reported stronger laboratory safety management practices ($F = 3.87$, $p < .05$). These results suggest that practical work experience and career stage play critical roles in shaping safety awareness and behaviors. Employees in mid-career stages may possess both the technical expertise and experiential learning needed to adopt and internalize safety practices effectively. This finding resonates with the safety maturity model, which posits

that organizations move through stages of safety culture development, with experience being a key driver of maturity (Fleming & Wentzell, 2008). For novice employees, safety practices may remain abstract, while for senior employees, complacency or routinization may diminish vigilance. Mid-career employees may thus represent the optimal balance of knowledge, experience, and engagement. Theoretical Implications. The study contributes to occupational safety theory in several ways. First, it highlights the discrepancy between individual and systemic safety behaviors, a distinction emphasized in theories of safety culture (Reason, 2016). While individuals are relatively compliant, organizational systems lag in providing infrastructure and preventive mechanisms. Second, the results support the behavioral-systems perspective on safety, which emphasizes that sustainable improvements require integration of both individual-level practices and system-level structures (Vinodkumar & Bhasi, 2010). Third, the findings on demographic influences enrich the understanding of how career stage interacts with safety behaviors, aligning with life-cycle theories of professional development (Super, 1990). Practical Implications, For practitioners, the findings underscore the need for targeted interventions in the Tak SEZ. While personal safety practices are strong, institutional investments must focus on 1) Enhancing laboratory safety management through comprehensive training programs on hazardous substances, infection control, and emergency procedures. 2) Improving facilities and infrastructure, particularly hazardous waste management systems, ventilation upgrades, and emergency response tools such as spill kits and contact systems. 3) Strengthening operational practices by institutionalizing risk analysis protocols and conducting regular emergency drills. 4) Promoting preventive healthcare, including vaccination programs and health monitoring, to complement individual protective behaviors and 5) Leveraging mid-career employees as mentors for junior staff, thereby transferring experiential safety knowledge and sustaining safety culture across generations of workers. These practical steps would align Tak SEZ laboratories with international best practices and help ensure both employee safety and organizational sustainability. Limitations and Directions for Future Research, Despite its contributions, the study has limitations. First, the reliance on self-reported survey data introduces the risk of social desirability bias, whereby respondents may over-report adherence to safety practices. Future research should incorporate objective safety audits or observational methods to triangulate findings. Second, the cross-sectional design prevents causal inference. Longitudinal studies could examine how safety perceptions and practices evolve over time, particularly in response to interventions. Third, the study was confined to one geographic and industrial context (Tak SEZ), which may limit generalizability. Comparative studies across different SEZs or sectors could shed light on contextual variations. Finally, future research should explore the role of organizational leadership and safety climate as mediating variables, given their well-documented influence on safety outcomes (Zohar & Luria, 2005). This study revealed that occupational safety risk management in the Tak SEZ is characterized by strong personal practices but moderate systemic support in laboratory management, facilities, and operations. The findings highlight the centrality of experience and career stage in shaping safety behaviors and underscore the importance of moving beyond individual compliance to systemic improvements in infrastructure, training, and emergency preparedness. From a theoretical perspective, the results affirm the behavioral-systems approach to safety management, while practically, they provide a roadmap for targeted interventions in training, infrastructure, and preventive healthcare. For policymakers and organizational leaders, the message is clear: cultivating a robust safety culture requires not only individual compliance but also institutional commitment to comprehensive, systemic safety management. In conclusion, while employees in the Tak SEZ laboratories exhibit commendable personal adherence to safety practices, sustainable occupational safety will only be achieved through the integration of individual behaviors with organizational structures, policies, and cultural reinforcements. This dual focus is essential for ensuring that laboratories remain safe, resilient, and capable of supporting both employee well-being and broader industrial development in the region.

Recommendations

1. Practical Recommendations

The findings of this study indicate that while employees in the Tak Special Economic Zone (SEZ) generally practice safe personal behaviors, organizational and infrastructural gaps remain significant. Therefore, it is recommended that employers and policymakers implement systematic occupational safety guidelines that prioritize laboratory safety management, waste disposal, and emergency preparedness. Regular training and refresher courses should be introduced for both new and experienced employees, with special emphasis on chemical handling, fire safety, and infection control. Furthermore, organizations should invest in improved infrastructure, such as ventilation systems, safety signage, spill kits, and hazardous

waste facilities, to ensure compliance with international occupational health standards. Health promotion initiatives, including regular medical checkups and vaccination programs, should also be integrated into workplace safety strategies to strengthen long-term workforce resilience.

2. Recommendations for Future Research

Future studies should expand the sample size to include a broader range of employees across different SEZs in Thailand to enhance generalizability. Longitudinal research designs could provide deeper insights into how safety behaviors and organizational practices evolve over time. Additionally, qualitative methods such as in-depth interviews or focus groups could complement survey findings by exploring employees' perceptions and experiences in greater detail. Comparative studies between SEZs and non-SEZ workplaces may also reveal structural and policy-related differences, thereby informing more tailored and effective safety guidelines.

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