ORIGINAL RESEARCH ARTICLE

Developing A Work-Related Accident Prevention Program for Onshore Pipeline Construction Workers in Thailand

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ABSTRACT

Background: Work-related accidents in construction are not only the cause of significant human suffering and loss; they are also complex phenomena involving multiple risk factors and stakeholders. Accordingly, numerous protocols and regulations have been developed to prevent construction work-related injuries in various settings. However, a specific accident prevention program has not been thoroughly investigated for construction workers in onshore oil and gas pipeline construction in Thailand. This study aims to develop and assess the effectiveness of an accident prevention program among onshore pipeline construction workers in Thailand.

Methodology: Mixed-methods research was conducted from March 2022 to March 2023 among 577 workers and 30 stakeholders in construction projects. The data were collected by a self-administered questionnaire and brainstorming. Multiple linear regression analyses, paired samples *t*-test, Safe-T-Score (STS), and content analysis were applied to analyze the data.

Results: The work-related accident prevention program, consisting of six steps with five proactive activities, effectively improved worker health and safety performance ($P < 0.001$). When compared to past performance, STS was less than -2 (STS = -2.18), which indicates an improved accident record. Worker health and safety performance was associated with poor environment (β = -0.146; P = 0.003), unsafe worker behaviors (β = -0.123; P = 0.026), unsafe workplace conditions (β = -0.466; P <0.001), and organizational psychology factors (β = 0.272; P < 0.001).

Conclusions: We recommend extending this program to other construction workers in related contexts to improve accident prevention and promote safe work practices.

Keywords: Health and safety performance, Safe-T-Score, Occupational exposure, Unsafe behaviors, Unsafe workplace conditions, Herzberg's two-factor theory

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Introduction

The International Labor Organization (ILO) reported in 2017 that more than 2.78 million people die per year as a result of occupational health and safety (OHS) hazards, an increase from 2.33 million at the end of 2014. In developing countries, the risk of work-related injury is 10 to 20 times higher than in developed countries.[1] Work-related accidents result in economic losses across multiple dimensions, such as medical expenses, workers' compensation, damage to production processes, reduced work efficiency, and decreased morale and motivation. The estimated losses account for approximately 4% of global GDP[1] and 6% or more of some countries' national GDPs. The burden of occupational mortality and morbidity is not equally distributed across the world: About two-thirds (65%) of global work-related mortality is estimated to occur in Asia,[2] and it is most common in the construction sector. The rate of work-related injury in the construction industry is high compared to other workplaces. These injuries often have severe consequences on the workers, their families, and the public.[2-3]

In Thailand, Workers' Compensation Fund reported that during the year 2012–2021, work-related injuries among all industries totaled 960,375. Of these, 10.01% occurred in the construction sector. Additionally, the fatality rate in the construction sector is the highest among all industries (18.98%),[4] and almost half (43.55%) of them are the Thailand's workforce labor population is aged 25–39 years old, which contributes to the country's economic value.[4-5] Additionally, Thailand's construction industry explicitly reported that its workers are 2.56 times more likely to be injured compared to workers in other occupations.[6] During 2012–2017, Thai construction workers were most likely to suffering injuries resulting in from disability (average 6 cases per year).[5]

Construction employees were at high potential health risk exposure to various factors in the workplace, including electrical shock, being hit or crushed by moving machinery, vehicle accidents, falling from height, structure failure, burns, bruising, fainting, coma, and death.[7-8] Additionally, most of the injuries occurred due to workers' *unsafe behaviors* (e.g., human errors, unskilled workers, carelessness, and downright recklessness),[9-10] *environmental factors* (e.g., dust, chemical vapors, volatile organic compounds, loud noise and vibrations from machinery), *unsafe working conditions* (e.g., poor housekeeping habits, high-voltage electrical, improper ventilation),[9-11] and *organizational psychology factors* (e.g., lack of knowledge, safety training, and safety motivation).[3,9] Poor safety performance creates a greater risk of workers facing work-related injuries or fatalities.[6-7]

Recognizing the impacts of work-related accidents in the construction sector and other industries, the ILO has launched a global strategy campaign focused on the concept of "sound management of safety and health at work" for achieving a strong preventative safety and health culture.[12] Thailand has recognized the importance of this issue, ratifying the ILO Convention No. 187 on March 23rd, 2016 to promote the establishment of a preventive safety and health culture in workplaces. The Thai government has also launched the Safety Thailand Reform Agenda under the "Thailand 4.0 model" beginning in 2016, demonstrating its commitment to implementing national policies in alignment with the ILO Convention. This initiative incorporates social dialogue mechanisms, engaging all sectors and levels (tripartite), dictating that workplaces must work together to promote workplace safety, with prevention as the key principle to effectively enhance safety policies and strategies.

Although the study of occupational safety promotion programs has been discussed,[13,14] research in this area remains limited particularly the study on safety culture promotion intervention programs that align with the ILO promotional framework in the construction industry. Additionally, Haghighi M. et al. suggest that continuous implementation of a safety culture promotion intervention program is needed to ensure the safety of workers, and is considered the top safety priority in pipeline construction and the oil industry.[15] However, in Thailand, no studies have been conducted to evaluate a safety culture promotion intervention program and test their effectiveness in onshore oil and gas pipeline construction.[16,17] We conducted a mixed-methods study to address this gap by exploring factors associated with health and safety performance and thence developed an appropriate work accident prevention program.

This study aims to develop and assess the effectiveness of an accident prevention program among onshore pipeline construction workers in Thailand.

Methodology

Study design and settings: A two-phase mixed-methods study was conducted from March 2022 to March 2023 at the construction site of the oil pipeline extension to the northeast region of Thailand (OPENE) project.

Study participants

Phase 1: Quantitative Phase: In phase 1, we explored the factors affecting worker health and safety performance using a cross-sectional study. Eligible participants were Thai workers in the OPENE project, aged 18 years or older, with no communication problems and who were willing to participate; those who returned incomplete questionnaires were introduced as extinction. To obtain an optimum or adequate sample size for the study objectives, Daniel's formula with a finite population correction was used.[18] A total of 830 construction workers were considered, with an estimated accident risk of 49%

(Haslam RA. et al.).[19] Using a 95% confidence level and a 3% margin of error, the final sample size was 577.

$$n = \frac{NZ^2\, P(1-P)}{d^2(N-1) + Z^2 P(1-P)}$$

Where, n is sample size with finite population correction, N *is* Population size (830), Z^2 is Statistic for a level of confidence (3.841), P is Expected proportion (in proportion of one) (0.49), and d is Precision (in proportion of one) (0.03).

Stratified sampling was employed to recruit the construction workers who met eligibility criteria. First, we divided them into six strata based on the international standard classification of occupations in general construction project: (1) Management and General Affairs, (2) Engineers and Specialists, (3) Construction Supervisors, (4) Foremen, (5) Skilled Labor, and (6) General Workers. Second, random samples were taken from each stratum to derive a representative sample of each occupation category to ensure that construction workers were selected and being truly randomly sampled as participants. A real random sample by lottery method was used from each category, and respondents were excluded if they were absent or unwilling to participate.[20]

Phase 2: Qualitative Phase: In the second phase, we employed action research to develop and evaluate the project for the accident prevention program by applying the concept presented by Kemmis and McTaggart (1988), which consisted of four stages: planning, action, observation, and reflection.[21] The researcher and co-researchers participated in this phase through co-thinking, co-practicing, co-observing, and co-reflection. This qualitative research was conducted from September 2022 to February 2023. We used purposive sampling for 30 stakeholders to participate in brainstorming sessions, including the occupational safety, health, and environment committee; project management representatives; worker representatives; and senior professional safety officers, who were selected by purposive sampling in order to obtain an in-depth understanding of the organization and its context, including the accident prevention intervention concept. Brainstorming is an effective conventional wisdom and is widely used to help organizations generate ideas; brainstorming sessions were conducted by the researchers and facilitated by the researchers' assistant. Therefore, OHS data analyzed from phase 1 were presented in the second phase, when a current situation on health and safety performance in the construction project was interpreted. A semi-structured questionnaire was used in two brainstorming sessions. In the first session, three issues were identified for situation analysis and possible problem statements: (1) work-related accidents in the pipeline construction sector, (2) problems of work-related accident prevention, and (3) measures for work-related accident prevention. In the second session, four issues were used to develop the program: (1) previous solutions for work-related accidents, (2) recommended solutions for these problems, (3) roles in preventing and solving work-related accident problems, and (4) an idea that has an element of newness or uniqueness of work-related accident prevention interventions. The qualitative data were analyzed and interpreted thematically using the method of Miles and Huberman (1994), consisting of (1) data organization; (2) data display; and (3) conclusion, interpretation and verification.[22] To test validity, we also conducted triangulation with experts and multiple researchers. Findings were discussed with team of researchers (peer debriefing).[23] In this study, three experts were invited as an investigator in the brainstorming session outline and after completing. Moreover, to confirm the accuracy of the data and researchers' interpretation of the results, participant validation was also conducted. Additionally, the item-objective congruence index of the brainstorming questionnaire ranged from 0.6 to 1.00. Furthermore, expert one of three was an observer in the second brainstorming session. The outcome of this step (planning phase) was an appropriate accident prevention program to be used in the operational steps (action phase).

Instruments: A self-administered questionnaire was developed based on the epidemiology theory of accident causation[24] to assess factors affecting worker health and safety performance, comprising the following six parts:

Part 1: Socio-demographic factors included gender, age, educational level, positions in the project, experience in the pipeline construction, and work-related accidents, with all categorical variables.

Part 2: Workplace-related factors consisted of four dimensions: environmental, organizational psychology, worker behaviors, and workplace condition factors. This was a five-point Likert scale, which involves scores ranging from 1 (least) to 5 (the most) as follows:

Environmental factors: We measured the physical, chemical, and biological environments that were affecting workers' health and safety in the project using a 17-item questionnaire. The total score ranged from 17 to 85, with higher scores indicating poorer environments for workers' health and safety. This measure had good internal consistency, with a Cronbach's alpha of 0.93.

Organizational psychology factors: We measured to understand how organizations affect individual behavior or feelings within the context of an organization or work environment using a 7-item questionnaire. The total score ranged from 7 to 35, with higher scores indicating greater organization management for workers' health and safety. The scale had strong internal consistency, with a Cronbach's alpha of 0.95.

Worker behavior factors: We measured the unsafe actions or behaviors exhibited by workers on construction projects using a 15-item questionnaire. The total score ranged from 15 to 75, with higher scores indicating more unsafe behavior. It had good internal consistency, with a Cronbach's alpha of 0.84.

Workplace condition factors: We measured to evaluate unsafe workplace conditions on construction projects using a 15-item questionnaire. The total score ranged from 15 to 75, with higher scores indicating more unsafe workplace conditions. It had good internal consistency, with a Cronbach's alpha of 0.93.

Part 3: Health and safety performance measured workers' health and safety performance in preventing illness and injury in workplaces, applying the element of OHS performance consisted of: (1) health and safety knowledge, (2) safe work behaviors, and (3) workplace conditions.[13-14] This was a 15-item questionnaire with a five-point Likert-type scale, ranging from 1 (poor) to 5 (excellent). The total score ranged from 15 to 75, with higher scores indicating greater safety performance. It had good internal consistency, with a Cronbach's alpha of 0.95.

Statistical Analysis

Quantitative Analysis: Descriptive analyses were performed for the participants' characteristics. The Kolmogorov–Smirnov test was used for normality testing. All continuous variables were normally distributed. We applied Pearson's correlation to examine the correlations between the selected variables and worker health and safety performance. Then, the stepwise multiple linear regression analyses were used to assess the associated factors of workplace-related factors. Furthermore, in the comparison of outcomes before and after the intervention, the paired sample *t*-test was used to compare the worker health and safety performance. All analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The significance level was set at *P*-value < 0.05. Additionally, Safe-T-Score (STS) was used to compare work units' past and present health and safety performance.[25] This tool returns three values: (1) STS between +2 and -2 indicates that health and safety performance showed no significant change, (2) STS more than +2 indicates that tendency towards decreased health and safety performance, and (3) STS less than -2 indicates that tendency towards increased improving health and safety performance.

Qualitative Analysis: Descriptive content analysis was performed to examine the qualitative data. Transcription of the audio recordings (verbatim) was analyzed and validated into categories according to similarity by two independent researchers. The brainstorming data were recorded and summarized by the researcher and research assistants.

The participants were informed about the research and its voluntary nature, which included a declaration of anonymity and confidentiality. All participants then provided written informed consent and completed a self-report questionnaire. This study was approved by the Ethics Committee for Research Involving Human Subjects, Mahasarakham University (ref.no. 102-046/2565).

Results

As shown in Table 1, most of the construction employees were male (89.91%), with a mean age of 36.55 years (SD = 9.89) ranging between 18 and 61 years. Approximately two-thirds (65.51%) had 3–8 years of experience in onshore pipeline construction, and about 49.91% were educated at an intermediate level. Roughly 64.12% held general labor or assistant jobs. Regarding accidents, 65.51% had no history with work-related accidents, and 25.48% had experienced a near-miss accident (Figure 1).

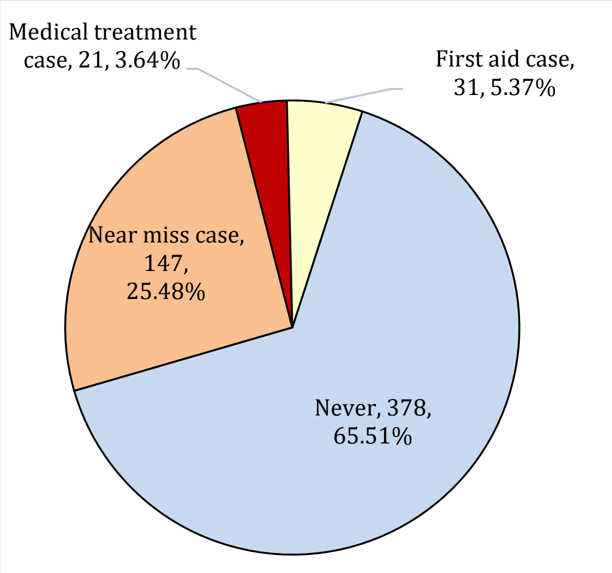

Figure 1: Work-related accident history in the past year (n = 577)

The mean scores of workplace-related factors were; environmental, organizational psychology, worker behaviors and workplace condition were 41.07 (SD = 9.54), 24.12 (SD = 2.11), 33.33 (SD = 5.80), and 29.82 (SD = 5.34), respectively (Table 2). The workplace-related factors' values measure the magnitude of workplace site exposure to each factor covered by this study; higher scores of all variables indicated poor conditions in the construction project, whereas lower scores indicated that the situation was safer—excepting organizational psychology, which was oppositely translated. Additionally, the mean score which indicating the workers' health and safety performance level in the study context revealed that 53.26 (SD = 4.39). This score was evaluated based on safety knowledge, safe work practices, and workplace conditions. An interpretation has two meaning: a positive situation (higher scores) indicates a tendency toward improved health and safety performance, whereas a negative situation (lower scores) indicates poorer or unsafe conditions.

Table 1: Distribution of Socio-demographic characteristics of construction workers (n = 577)

Variables	Participants (%)
Gender	
Male	513 (89.91)
Female	64 (11.09)
Age (years)*	
18–39	354 (61.35)
40–59	219 (37.96)
≥ 60	4 (0.69)
Education*	
Basic (lower secondary)	237 (41.08)
Intermediate (upper secondary)	288 (49.91)
Advanced (bachelor's or equivalent)	52 (9.01)
Experience in pipeline construction (years)	
<3	57 (9.88)
3–8	378 (65.51)
9–14	100 (17.33)
≥ 15	42 (7.28)
Positions	
Management level & Operation support	17 (2.95)
Engineer and other specialist	18 (3.12)
Supervisor	8 (1.39)
Foreman	24 (4.16)
Skilled labor	140 (24.26)
Helper/General labor	370 (64.12)

Note: (1) According to Thai labor law, construction work is a high-risk activity and as such, it is prohibited to hire employees younger than 18; (2) Age categories based on the age grouping standards of the Ministry of Labor; (3) mean = 36.55 years (SD = 9.89), min. = 18 years, max. = 61 years; (4) Education classification based on International Standard Classification of Education (ISCED).

Table 2: Workplace-related factors and worker health and safety performance (n = 577)

Factors	Mean	SD
Workplace-related factors		
Environmental factors	41.07	9.54
Organizational psychology factors	24.12	2.18
Workers' behaviors factors	33.33	5.80
Workplace condition factors	29.82	5.34
Workers' health & safety performance	53.26	4.39

Note: SD = Standard deviation

The results revealed that environmental, organizational psychology, workers' behaviors, and unsafe workplace conditions in the project were correlated with worker health and safety performance ($P < 0.05$; Table 3).

The stepwise multiple linear regression analysis was used to adjust and examined the influence of four factors environmental, organizational psychology, workers' behaviors and workplace condition on health and safety performance. After adjusting for all other predictors. A fitted model was statistically significant, which was used to predict the worker health and safety performance of 28.2% (Table 4). Workplace condition was the variable with the most direct effect on the level of health and safety performance in the model. The stepwise multiple linear regression analysis revealed that worker health and safety performance was negatively associated with workplace conditions (β = -0.466; $P < 0.001$), environment (β = -0.146; P = 0.003), and workers' behaviors (β = -0.123; P = 0.026). Unsafe workplace conditions, poor environment, and unsafe behaviors of the workers were significantly associated with lower of health and safety performance by 0.46, 0.14, and 0.12, respectively. However, health and safety performance was positively associated with organizational psychology (β = 0.272; $P < 0.001$); when the level of organizational psychology was increased, the health and safety performance level was significantly increased by 0.27.

In phase 2 (planning phase), all stakeholders were involved in planning to develop a work-related accident prevention program using the AIC technique. We presented the quantitative results, such as the predictor variables of worker health and safety performance (i.e., environmental, organizational psychology, workers' behaviors, and workplace conditions) and the preliminary data of the accident prevention project in the construction sector and its context.

Table 3: Correlation between selected variables and worker health and safety performance (n = 577)

Variables		Y	X1	X2	X3	X4
Worker health and safety performance	(Y)	1				
Environmental factors	(X1)	-0.11*	1			
Organizational psychology factors	(X2)	0.37**	-0.19**	1		
Workers' behaviors factors	(X3)	-0.14*	0.27**	-0.11**	1	
Workplace condition factors	(X4)	-0.41**	0.26**	-0.18**	0.57**	1

Note: ** P < 0.01, *P < 0.05

Table 4: Multiple linear regression analysis toward worker health and safety performance (n = 577)

Variables	B	SE	β	*t*	95% CI of B	*P*-value
Environmental factors	-0.074	0.025	-0.146	2.994	-0.250, -0.122	0.003*
Organizational psychology factors	0.591	0.103	0.272	5.756	0.389, 0.792	<0.001*
Workers' behaviors factors	-0.103	0.046	-0.123	2.236	-0.212, -0.194	0.026*
Workplace condition factors	-0.431	0.052	-0.466	-8.351	-0.533, -0.330	<0.001*

R = 0.539, R^2 = 0.290, R^2Adj = 0.282, F = 35.854, P < 0.001, R^2 change = 0.10

Note: Adjusted for gender, age, educational level, experience in the pipeline construction, positions, work-related accident
B, unstandardized coefficients; SE, standard error; β, standardized coefficients; CI, confidence interval
*Statistically significant at P < 0.05.

The impact of work-related accidents—particularly in the construction sector—remains continuously high. In this stage, we designed and developed a work-related accident prevention program, which consisted of five proactive activities that would be used in operational steps. Top management examined the action plan and decided to move forward with it.

In the operational steps (action phase), we applied the work-related accident prevention program developed in the planning phase, comprising five proactive activities:

(1) Knowledge Management: The objective of this activity was to improve the construction workers' knowledge and life skills in accident prevention. Work-related accident cases that had occurred in the past projects were presented by supervisors and project management personnel during the weekly toolbox meeting activity, and risk identification was analyzed in order to determine appropriate prevention measures. The educational materials (e.g., health and safety bulletins, pamphlets, posters) were posted around the project site and uploaded to the online application. Moreover, safe work behaviors and workplace conditions in the project were observed through the proactive safety campaign (in the second activity).

(2) See-Say-Do activity: This activity is based on the idea that everyone has a role to play in ensuring workplace health and safety. Thus, all workers will watch for unsafe practices and/or unsafe working conditions in their workplace (See), and they all have an obligation to inform colleagues and report any unsafe practice or/and unsafe conditions without bias (Say). Any worker who observes or sees something can say something. Finally, workers are also encouraged to take action (Do) without negative feedback from the others, such as reporting unsafe practices. Smartphones were used to report any critical issue that could endanger the health and safety of the employees, project properties, or third parties, allowing for problem-solving immediately.

(3) Health and Safety Motivation: The aim of this activity is to sustain a continuous "See-Say-Do" campaign by applying Herzberg's two-factor theory of motivation.[26] "See-Say-Do" data were collected by the health and safety department and workers were randomly chosen to receive a special incentive provided by project management. The concept of this activity was designed to seamlessly bridge to the first and second activities; those proactive activities would allow the workers to change their safety mindset.

(4) Encouragement: This activity involved encouraging job satisfaction and building a positive working environment. When employees receive a compliment, it is a special reward of recognition for reaching goals or producing high-quality work. This activity was designed to seamlessly bridge to the first, second, and third activities; meanwhile, it was reinforced by this activity to allow the construction workers to change the safety mindset. If a worker determined the best practice for preventing work-related accidents, they could report it to the health and safety committee or project management. Then, their recognition with a certificate of best practice would be announced by project management during the weekly and monthly toolbox meetings.

(5) Networking: We cooperated with the other construction project, the occupational health and safety regulator, and the other organizations involved in health and safety promotion (including institutional education and local administration organizations) to share the strategies and resources for solving work-related accident problems.

In the observation stage (follow-up phase), the implementation of operational models to prevent and solve work-related accident problems in onshore pipeline construction projects was evaluated. We implement this program among 99 construction workers working on the OPENE project. After the intervention, the workers had a significantly higher mean score of health and safety performance than before (P < 0.001; Table 5). Safe-T-Score (STS) is a statistical control technique to indicate the effectiveness of the work accident control program by comparatively assessing health and safety performance in the past and present.[25] An STS value below -2.00 indicates improvement in the health and safety performance record. Our STS value showed a significant decrease (STS = -2.18) since the implementation of the project, indicating that the health and safety performance record was improving and that the program was having positive effects which should be maintained (Table 6).

In the reflection phase, the researcher and co-researchers presented the accomplishments of all activities and, with all the stakeholders, discussed the concept of a work-related accident prevention program that was suitable for the OPENE project.

Table 5: A comparison of worker health and safety performance between before and after intervention

Workers' health and safety performance	n	Mean	S.D.	Mean difference	95% CI	df.	*t*	*P*-value
Before intervention	99	53.41	4.56					
After intervention	99	63.97	3.99	10.56	10.5–10.87	355	66.63	<0.001*

Note: *Statistically significant at P < 0.05.

The operational model for preventing and solving work-related accidents in the construction of on-shore pipelines consists of six steps: (1) establishment of an operating committee, (2) improvement of knowledge and life skills, building a positive mindset and safety awareness, (3) communication and reporting channel, (4) motivating and encouraging, (5) work-related accident prevention network, and (6) evaluation and continuing improvement. Additionally, we discussed the limitations and strengths of the project; it was concluded that the key factors in the project's success were management support, worker participation, safety mindset, and project stakeholders. Furthermore, the accident prevention model was found to be an effective intervention in preventing work-related accidents. These findings suggest that prevention strategies should focus on enhancing human behaviors and workplace safety, as well as improving safety attitudes, peer relationships, construction project bonding, and work-related accident prevention behaviors.

Table 6: A comparison of Safe-T-Score between before and after intervention

	Before intervention 1 May 2022 – 30 September 2022	**After intervention** 1 October 2022 – 28 February 2023
Safe-T-Score	**-0.87**	**-2.18**

Note: The Safe-T-Score (STS) is a standard method of quantitative measure for evaluating organizations' safety performance. It is also used to compare a work unit's past and present accident rates.

Interpretation:
1) STS between +2 and -2 indicates that the work accident control program showed no significant change.
2) STS above +2 indicates that the program has decreased safety performance.
3) STS below -2 indicates that the program has improved or is improving safety performance.

Discussion

This study demonstrated that increased unsafe worker behaviors were associated with decreased safety performance, corroborating prior research on construction accidents in Thailand, which reported that most accidents (88.97%) were associated with unsafe acts.[27,28] Our findings also corroborate the theories of accident proneness and dominoes, which suggest that unsafe conditions or unsafe behaviors trigger the sequence leading to injuries.[24,2-30] Thus, because workers' behaviors are an extremely important factor in workplace safety, promoting safer practices were associated with higher safety performance and reduce injuries on a construction project. Also, the identification of unsafe work behavior of employees in advance may help considerably in the development of remedial measures and strategic actions to prevent accidents.[28-31]

We also found that environmental factors (physical, chemical and biological) were associated with the safety performance level: Poorer environments were associated with reduced worker health and safety performance. Our study supports prior investigation by Sawacha E. et al., who reported that sites with good environments that are well planned (layout) and kept tidy tend to have high safety performance levels.[28] Numerous previous studies indicate that unsafe working environments are negatively related to workers' safety performance and accident frequency.[28,32,33] Better work environments are known to have a robust effect on employees' safety performance and safety management practices, whereas unsafe working environments lead to more construction accidents.[8,28,33,34] Some studies indicated a positive correlation between work-related injuries and occupational exposure to a wide variety of occupational hazards, such as dust and fumes (particularly welding fumes in outdoor pipeline construction)[32-35] as well as biological hazards.[32,35,36] Thus, a lack of environmental control was associated with increases the risk to health and safety, although several studies indicate that it can be improved by adopting safety rules and regulations during construction. The authors suggest that risk identification and proper planning prior construction commencement would be better.[30,32,33]

Moreover, our findings indicate that improved organizational psychology was associated with increasing worker health and safety performance. This finding adds further support to many earlier studies, including that by Shamsuddin KA et al., who indicated that organizational commitment and communication is the main factor affecting construction workers' attitudes toward health and safety.[30] Additionally, Yuliana L. and Adhyaksa D also found that lack of management support, poor management commitment, and insufficient safety knowledge and training led to unsafe actions by construction workers.[10] According to previous studies, organizational psychology makes a significant contribution to shaping human resource management strategies and designing safe work environments that support employee safety performance.[29,36,37] Construction workers may perform unsafe activities due to a lack of management support, poor management commitment, and inadequate worker safety understanding and training; thus, management commitments are significant influences on construction safety.[9] Similar findings were seen in the study done by Mearns J and Reader T, reported that; organizational support, health and safety support from supervisors and workmates were positively relationship with workers' safety behaviour in the workplace.[38] These empirical findings can be used by decision makers, construction policy makers and other stakeholders to apply organizational psychology in improving construction productivity, promoting health and safety and thereby decreasing work-related accidents.

We also found that unsafe working conditions were related to reduced worker health and safety performance. This finding adds further support to earlier research indicating that unsafe conditions are the second most important factor contributing to work-related accidents.[6,9,19,36] However, an analysis of unsafe actions and unsafe conditions based on occupational health and safety card reporting programs in Indonesia, conducted by Yuliana L. and Adhyaksa D., revealed that unsafe conditions are reported more often than unsafe actions.[10] Moreover, Haslama RA. et al. concluded that poor workplace conditions (e.g., poor housekeeping, inappropriate site layout and inadequate working space) contributed to half (49%) of the accidents studied.[19] Many studies indicate that unsafe workplace conditions (hazardous physical conditions or circumstances) can directly lead to accidents. Both unsafe physical and psychological circumstances are hazard risks, and they are the main cause of construction accidents. Furthermore, unsafe workplace conditions were also associated with lower safety performance.[9,31] However, considering accident causation theories, OHS researchers have discussed that many accepted techniques exist that can help prevent work accidents. Therefore, to make a construction workplace safer, the authors recommend that all construction site stakeholders involved should conduct hazard identification in the workplace and hazard analysis to determine the appropriate hazard treatment or action to ensure a safer workplace with adequate protection, thereby eliminating or reducing the workplace risk to an acceptable level. Thereafter, continuous monitoring, reviewing, and improvement is recommended.

Furthermore, the operational model developed for the work-related accident prevention program had a strongly positive outcome, increasing workers' health and safety performance in the construction project. As an operational step, the intervention focused on promoting work-related accident prevention among the construction workers, which consists of: knowledge about the prevention of work-related accident, awareness, a proactive motivating program, encouraging a safety mindset, and increasing the participation of project management personnel to commit to occupational health and safety objectives. Our findings add further support to earlier studies[29-30,39] such as Haghighi M et al.[15] who conducted a safety culture promotion intervention program (SCPIP) on Tehran refinery workers; two months after implementing the SCPIP in the experimental group, the level of total cognitive factors toward safety culture was significantly increased and remarkably improved. Yuliana L. and Adhyaksa D. conducted an intervention to reduce accidents by the use of "OHS report card" programs,[10] In practical terms, the outcome of the OHS report card program was similar to that of our "See-Say-Do" program. According to the literature review and our phase 1 findings, we considered the important influence of frontline personnel, which includes the project management team; supervisors play key roles in accident prevention. We also found that organizational psychology was strongly associated with health and safety performance; therefore, we strengthened participation in the intervention program during operational phase by applying Herzberg's two-factor theory of motivation[26] to encourage workers to be more enthusiastic about safety in the workplace and engagement in safety programs. This led the workers to greater ownership of issues relating to their safety, resulting in greater engagement in creating a safe workplace and engagement in safety programs. In this study, we employed motivation factors: (1) Recognition; positive recognition was appeared when workers receive praise or rewards (for reaching specific goals at their job or reporting of See-Say-Do), (2) Responsibility; which involves both responsibility and authority in relation to the job, and (3) Work itself and achievement. Whereas, job satisfactions or hygiene factors was also employed: (1) Working conditions; such as improving workplace environment by See-Say-Do campaign, (2) Participation and peer relationship; (3) Supervision; Supervisor and Manager role and responsibilities in the construction site and (4) Management commitment; poor leadership or management in the construction site may decrease the level of job satisfaction in the workplace and also may be decrease the level of health and safety performance.

Six months after the intervention, health and safety performance was significantly increased according to the remarkably improved measure of STS. In this study, all factors involve the physical surroundings of the construction context (workplace conditions); supervision, peer relationships, and organizational psychology are the hygiene factors; and, responsibility, recognition, work itself, and achievement are the motivation factors. The See-Say-Do program was designed to gather all construction personnel involved to participate in a health and safety campaign; management commitment and full participation is the key to success. Chen D. and Tian H. indicate that praising and encouraging workers' safety behaviors and communication within the team and supervisors contribute to a culture of safety as well as increased morale. In addition to praise and recognition, our program also focused on improving workers' health and safety knowledge,[40] which evidence suggests is very important, especially for educating employees about safety practices and compliance such as accident prevention and control. Increased health and safety knowledge may decrease workers' risk of work accidents [30-31,39-40] and improve their life skills and awareness of safety work practices.[40] Finally, safety performance may be improved by cognitive factors and support from the organization, supervisor, and project management personnel in relation to health and safety issues, such as intervening to assist work colleagues and reporting hazards (e.g., See-Say-Do program).

Strength and Limitations

This study has some limitations. First, this study was conducted at a unique onshore oil and gas pipeline construction project, which may limit its generalizability to other industries. Second, we cannot establish causal relationships due to the cross-sectional design of the study; longitudinal research is needed to investigate the causal relationships among the variables. Third, the self-reported measurement may be vulnerable to social desirability bias; to minimize self-report bias, validated and standardized instruments were used. Despite these limitations, our research provides important new information about the worker health and safety performance of a unique construction sector as well as its influence on various aspects of work-related factors (e.g., environmental, unsafe behaviors, unsafe conditions, and organizational psychology). The authors recommended that this study's insights, as well as the model we have developed, be applied to other construction contexts. Other industries may also adopt the strength of the program (i.e., motivating technique) to allow their employees to fully engage with workplace health and safety, which is empowered by management's commitment.

Conclusion

This study highlights the importance of addressing workplace safety through behavioral and environmental interventions. The proposed six-step accident prevention program significantly improved safety performance and reduced accidents. Future studies should validate this model across different construction settings in Thailand.

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